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TECHNICAL MANUAL

IES 989

OPERATOR'S AND ORGANIZATIONAL MAINTENANCE MANUAL

FOR

TESTER, DENSITY AND MOISTURE

(SOIL AND ASPHALT) NUCLEAR METHOD CAMPBELL PACIFIC MODEL MC-1 (CCE)

(NSN 6635-01-030-6896)

HEADQUARTERS, DEPARTMENT OF THE ARMY

SEPTEMBER 1985

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WARNING

RADIOACTIVE MATERIAL

Cs 137 and Am 241

The tester shall immediately be withdrawn from use when the wipe test indicates a reading of 0.1 mrem/hr or more, or when the analysis laboratory test results reveal the presence of 0.005 or more microcuries.

A tester is contaminated when a reading of 0.1 mrem/hr or more is obtained from the swab. Follow procedure provided in paragraph 4-7.3. The swab is also contaminated.

Pregnant personnel are not authorized to handle, operate, or maintain the tester.

Do not smoke, eat, or drink while handling the tester.

Under no circumstances shall the tester be conveyed to a property disposal officer. All disposal actions shall be conducted in accordance with AR 385-11.

The tester contains two sealed sources: cesium (Cs) 137 and americium (Am) 241. The sources are also double-encapsulated in stainless steel. Classified as special form. Ten millicuries of Cs 137 is in the probe tip and produces gamma radiation. A 50 millicurie mixture of Am 241 and beryllium (Be) is located within the tester next to the probe and produces fast neutrons.

The tester shall only be used by trained operators who are under the direction of a radiological protection officer.

The tester operator shall not stand unnecessarily close to the tester, and shall not carry the tester except by its carrying handle.

Good radiation protection begins with always concentrating on maintaining maximum distance from the sources, and always operating the tester with speed and efficiency.

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WARNING

The tester presents minimum hazard to the operator and the general public when it is used in accordance with procedures provided in this manual.

Do not attempt tester repairs. A faulty tester must be returned to a designated manufacturer's repair facility.

WARNING

Always wear your beta-gama badge when operating the tester and upon entering tester storage areas, and at other times as directed by the Local Radiation Protection Officer (LRPO).

WARNING

Insure the tester handle is placed in the safe position prior to placing the tester into the approved carrying case.

WARNING

Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in well ventilated area. Avoid contact with skin, eyes, and clothes, and don't breathe vapors. Do not use near open flame or excessive heat. The flash point for Type #1 Drycleaning Solvent is 100°F (38°C) and for Type #2 is 138°F (50°C). If you become dizzy while using cleaning solvent, get fresh air immediately and get medical aid. If contact with eyes is made, flush your eyes with water and get medical aid immediately.

WARNING

Under no circumstances shall the testers be conveyed to a property disposal officer. All disposal actions shall be conducted in accordance with AR 385-11.

WARNING

Before proceeding to the next decontamination level, contact the Commander, TACOM, ATTN: AMSTA-CZ for guidance concerning respiratory protection. Failure to wear respiratory protection may result in overexposure to radiation.

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Technical Manual

No. 5-6635-386-12&P

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C. *10 September 1985*

TESTER, DENSITY AND MOISTURE (SOIL AND ASPHALT) NUCLEAR METHOD CAMPBELL PACIFIC MODEL MC-1 (CCE) (NSN 6635-01-030-6896)

REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS

You can help improve this manual. If you find any mistakes or if you know of a way to improve the procedures, please let us know. Mail your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms), or DA Form 2028-2 located in the back of this manual direct to: Commander, US Army Tank-Automotive Command, Warren, MI 48090, Attn: AMSTA-MB. A reply will be furnished to you.

This technical manual is an authentication of the manufacturer's commercial literature and does not conform with the format and content specified in AR 310-3, Military Publications. This technical manual does, however, contain available information that is essential to the operation and maintenance of the equipment.

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SECTION I

GENERAL OPERATING INSTRUCTIONS

GENERAL INFORMATION

The Density and Moisture Tester (Soil and Asphalt) measures density and moisture of construction materials using radioactive sources and internal electronics.

Measurements can include the determination of percent compaction of soils and asphalt pavements, density and moisture of concrete, roofing materials, wallboard, woodchips and other construction related materials.

A Basic Tester Kit includes:

Density and Moisture Tester, Std. 8" transmission, dual backscatter,
NSN 6635-01-030-6896 (CPN model MC-1)
Cast aluminum Guideplate
Computer Tabulations
AC Charger
DC Charger (Batt. clips)
Sign Set
Phillips Screwdriver
Fiberglass Transportation and Storage Case (with key-alike padlock)
Tester handle key
Standard Drill Pin

Optional Accessories:

10 and 12" depth for transmission
1" increments

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Unpacking

Damage upon receipt is the responsibility of the freight company. A claim should be filed with the freight company for damage. If the radioactive source may have been damaged, see paragraph 4-7.3.

1-1.00 GENERAL OPERATION

The tester is ready for use after unpacking.

On overseas shipments or where known long term storage is involved, the batteries may have to be installed. Refer to Section III for instructions.

There are no adjustments in the tester. All settings are factory set and sealed.

If the batteries are low, a letter "L" will appear in the display. If the batteries are very low, the gauge will "cutout". The "L" will appear, but the gauge will not operate. Recharge or replace the batteries.

Charge the tester overnight when the batteries indicate "L" or low. The batteries cannot be damaged by overcharging.

A satisfactory automatic program would be to charge the tester over a weekend once or twice a month depending upon use.

Due to excessive damage caused by battery leakage, only NICAD batteries, NSN 6140-00-497-0490, will be used as replacement. Quantity of eight (8) each should be ordered.

DO NOT ATTEMPT CHARGING ALKALINE BATTERIES. ALKALINE BATTERIES ARE NOT TO BE USED IN THE TESTER.

DO NOT ATTEMPT CHARGING ZINC-CARBON BATTERIES. ZINC-CARBON BATTERIES ARE NOT TO BE USED IN THE TESTER.

Shipping Case

The shipping case is a fiberglass case with integral, molded foam padding (see paragraph 3-4.0 for shipping case maintenance).

Reference Standard

The reference standard is carried in the fiberglass case.

Reference standards are serialized for each tester, however, they are interchangeable between testers.

Guideplate

The guideplate is cast aluminum. It is entirely adequate for all surfacing and for support of the drillpin during transmission hole preparation.

Do not use the plate to remove the drill pin!

Drill Pin

The standard drill pin is 3/4 inch diameter with a forged head.

1-1.01 MODES OF OPERATION

BACKSCATTER is the technique of placing source and detector on the surface of a flat material. This technique measures only the top 2-inches of soil and is very sensitive to surface roughness or quality of site preparation.

TRANSMISSION is the technique of predrilling a small hole in the ground and then inserting the radioactive source in the ground via the movable source rod. This technique permits measurement to specific depths to 12-inches and is insensitive to surface roughness. It is very accurate and is the preferred method of measurement for soils.

DENSITY is measured by either of the two above techniques.

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MOISTURE is measured by backscatter only. It is not a transmission phenomenon. The tester uses a separate source in the bottom casting to insure constant backscatter operation and permit simultaneous counting of both density and moisture.

Moisture obtains approximately 90% of its returned thermal neutrons from the closest 6-inches of soil.

1-1.02 PRINCIPLES OF OPERATION

General

Various elements, both naturally occuring (Radium) and reactor produced (Cesium and Americium) are unstable and are slowly decaying to a more stable state. The act of decay produces emissions of energy upon disintegration of the atoms. These emissions are either "rays" of electromagnetic radiation (Gamma Rays) or are actual particles of material (neutrons, for example). Other emissions are produced from various radioactive materials; however, we are concerned with only the gamma and neutron radiation for purposes of nuclear soil testing.

Gamma radiation occurs spontaneously from the Cesium or Radium source material.

Neutron emission occurs when an alpha particle emitter (Americium, Plutonium, or Radium) is mixed with Beryllium powder in a tightly compressed pellet. The alpha particles strike the Beryllium atoms to produce fast neutrons of an average energy of 5 million electron volts (MEV). The suffix "Be" is attached to the alpha source name to denote its use as a neutron source when it is mixed with Beryllium (RaBe, AmBe, PuBe).

These emissions are detected by appropriate detectors (Geiger Mueller tubes) for gamma and (Boron Tri-fluoride-BF3 or Helium-3 H3 tubes) neutron measurements. The resultant signals are displayed electronically as an index of soil density and moisture.

Radioactivity, both gamma and neutron, may be thought of as being similar to light from an incandescent bulb. The light rays diminish rapidly as we move away from the bulb (by the inverse square of the distance from the lamp), and they have the ability to penetrate various materials to some degree, ranging from nearly complete penetration (glass) to nearly complete blockage (metal shield).

Radiation obeys the same rules, although its penetration capabilities are generally much greater than light. The farther we are from the source, the safer we are, and the more absorbing material (shielding) we place between ourselves and the source, the safer we are. It is theoretically impossible to shield any radioactive source completely; however, careful tester design and appropriate choice of shielding materials can reduce the radiation to an acceptable level with negligible absorption by the user under proper operating procedures.

Gamma Radiation

Gamma radiation is electromagnetic "photon" energy capable of penetration of several inches of most materials. It is essentially high energy "light ray" energy. It is useful for the total mass measurement of heavy materials and is used to determine total density of soil.

Gamma radiation is emitted in several energy levels by a sealed Radium source and in a single energy level by a Cesium source. The Cesium level is 0.66 MEV and requires less shielding than the multi-level output of the Radium source. The fixed spectrum emission is also superior for soil density determination purposes. Cesium, a reactor produced

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isotope requires a license for use anywhere in the U.S. and in foreign countries.

Neutron Radiaton

Neutron radiation consists of small, noncharged particles emitted from the source at an average energy level of approximately 5.0 MEV. This is known as "fast" neutron emission. Neutron detectors "see" only slow, or "thermal" neutrons, therefore, the fast neutrons must slow down or they will be ignored by the detectors. Neutrons slow down by colliding with other objects much like a rifle bullet richocheting from rock to rock.

Collision of the fast neutrons with the nuclei of large atoms results in rebounding of the neutrons with little loss of energy. Collision with the orbiting electrons (approximately 1/1840th the weight of a neutron) produces little loss of energy. However, collision with an object of the same mass will produce a major loss of energy or slowing down.

The only atom which can markedly slow down a fast neutron, and which we would likely see in soil, is hydrogen. The hydrogen nucleus is the same mass as the neutron and slows down the neutron immensely compared to collisions with other nuclei. The greatest loss of energy in any collision is when two similar mass objects collide.

A simple analogy is that of a golf ball colliding with a bowling ball. The golf ball would rebound with little loss of energy. The golf ball colliding with BB's (electrons floating around a nucleus) would push them aside. However, two golf balls colliding would produce a strong loss of energy in each of them, or a transfer of energy from one to the other.

This is what happens when a fast neutron hits a hydrogen atom. The neutron is markedly slowed down. A few collisions with hydrogen atoms reduces a fast neutron to the slow or "thermal" energy at which the moisture detectors in the soil tester can "see" the slow neutron.

Thus, the moisture channel is in reality a "Hydrogen Analyser" and is responsive to any form of hydrogen present whether it be in the form of water, or of some organic matter. It is possible to measure water on a construction site because the only form of hydrogen we normally see on a soil site is free water, the very feature we are trying to measure. However, bound water within the mineral matrix, organic matter, roots, or asphalt in an asphalt pavement would also provide hydrogen moderation and the neutron tester would "read" it accordingly. If we know the quantity of extraneous hydrogen, we can account for it in calibration and the tester can still be used for moisture determination.

Neutron radiation is emitted by any alpha producing source when mixed with Beryllium. CPN uses Americium/Beryllium (AmBe) source in its soil testers.

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1-1.03 PANEL CONTROLS

Refer to Keyboard (Fig. 1-1) - Each Touchkey is outlined below.

MODE SELECT - (PROGRAMMING)

CLEAR = Stops count in progress, stores this count, does not reset this count to zero. Cancels any other prior program keys (D or M-ONLY).

Pushing a display touchkey will produce a display of the stored count. Note that the tester will go through its normal, rapid shutdown "beep" to alert the operator that the tester was stopped deliberately and not automatically.

LOCK = Interlocks TEST and STANDARD to prevent accidental field actuation of either of these two functions. LOCK by itself will do nothing.

STD = When pressed simultaneously with LOCK, will erase all four memories and will initiate a 4 Minute count into all four memories. This provides a check on the performance of the memories. The stored readings are normalized to the 1/4 minute time base for ease of operator computation. STD by itself will do nothing.

The two STANDARD memories will be retained for future recall. Pushing any of the 4 OPERATIONS buttons will erase the standard count stored in the D-DATA and M-DATA memories and they will count normally.

TEST = When pressed with any DISPLAY key, will light all 8's to test the display and the display command system. When pressed alone, it displays a random number which should be discarded.

When pressed simultaneously with LOCK, will erase all four memories and will initiate a 1 minute count into all four memories. The displays will each read 65536 if the test signal has been properly processed. This tests all digital circuitry in the tester, but does not test the analog circuitry (high voltage supplies).

NOTE

After approximately Jun 78, TEST will count 1/4 minute and will display 16384. This shortens TEST time as a convenience.

D-ONLY = When pressed the tester will count Density Only, retaining last moisture count. D-ONLY is cancelled by pressing an Operations Key or by pressing CLEAR.

M-ONLY = Same as D-ONLY except that only moisture is counted.

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OPERATIONS (START)

1/4 - MIN (STAT - CHECK)	=	Initiates 1/4 minute count cycle. Use for Statistical check per Paragraph 1-2.01.
1/2 - MIN	=	Initiates 1/2 minute count cycle.
1 - MIN	=	Initiates 1 minute count cycle.
2 - MIN	=	Initiates 2 minute count cycle.

PRECISION OF VARIOUS TIME PERIODS

(Read Para 1-2.01 through 1-2.03)

NOTE: ALL DISPLAYS NORMALIZED to 1/4 Minute.

(in PCF @ 120#)	1/4	1/2	1	2
BS	1.20	.85	.60	.42
AC	1.00	.71	.50	.35
6"	.50	.35	.25	.18
H20	.50	.35	.25	.18

Legend:
PCF - Pounds Per Cubic Foot
BS - Backscatter
AC - Asphaltic Concrete

NOTE Pushing any Operations key will immediately restart tester and will supersede prior command.

DISPLAY

D - DATA	=	Displays Density count.
M - DATA	=	Displays Moisture count.
D - STD	=	Displays Density standard count.
M - STD	=	Displays Moisture standard count.

Upon initial operation after a period of nonuse, press the CLEAR key to clear out any unwanted commands.

Press any of the four OPERATIONS keys to start the tester for normal density and moisture counting. All displays will be normalized to a 1/4 minute count base for simplicity of computation.

At the completion of any count cycle, the tester will "beep-beep" rapidly for ten beeps.

During the count cycle a steady "beep" will be heard.

If the batteries are low, but still useable, an "L" will appear in the display window. If the batteries are below acceptable charge level, the "L" will display, but the tester will "Cutout" and will not operate. Recharge the batteries.

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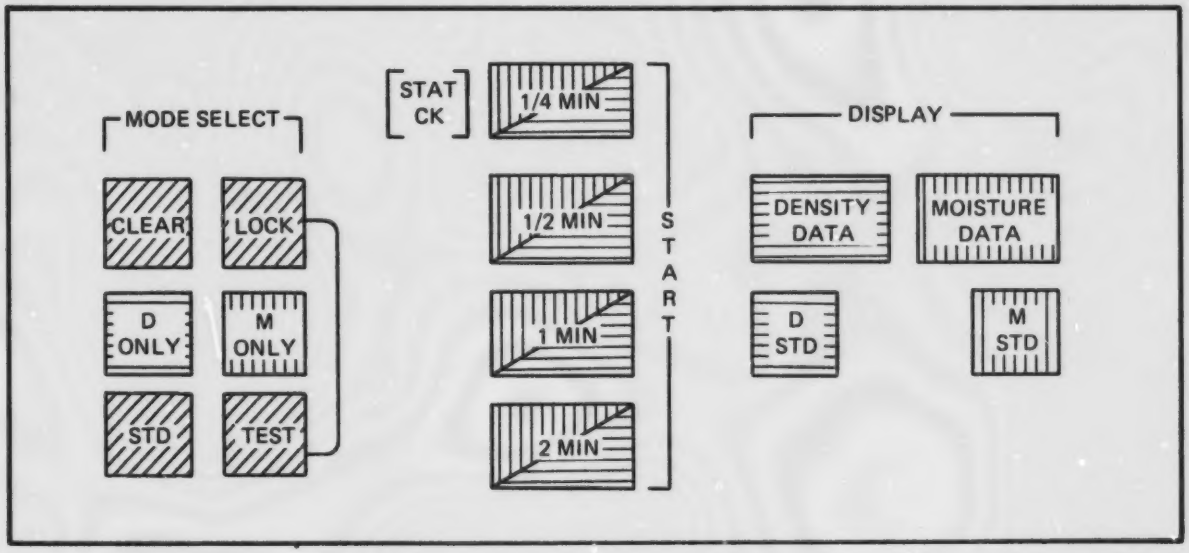

Figure 1-1. Keyboard Configuration

1/4, 1/2, 1 or 2	=	SIMULTANEOUS COUNT OF BOTH CHANNELS
TEST + ANY DISPLAY	=	LAMP TEST (88888)
TEST + LOCK	=	INTERNAL CHECK (65536) (16384 after 7/78)
STD + LOCK	=	STANDARD COUNT (4 MIN)
D-ONLY or M-ONLY	=	ONLY COUNT ONE CHANNEL

NOTE

Some testers do not have the D-only or M-only keys.

CLEAR	=	STOP COUNT (Does not reset to zero)
D-DATA or M-DATA	=	DISPLAY LAST FIELD COUNT
D-STD or M-STD	=	DISPLAY LAST STD or TEST COUNT

NOTE

All count periods are "normalized" to a common time base of 1/4 Minute to reduce operator work in the field.

After approximately July 1978, Internal Check (TEST + LOCK) will count only 1/4 Minute and will display 16384.

Both TEST/LOCK and STD/LOCK count into all four channels as a cross check for counting accuracy.

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If nothing at all happens when the touchkeys are pressed, the batteries are completely discharged or are disconnected.

If a mistake is made in starting the count, clear the tester with the CLEAR key and restart the sequence. This will clear all stored commands. If an erroneous time cycle was pressed, it is necessary only to press the correct touchkey to restart on the correct time cycle.

To take a density count only and NOT take a moisture count, press D-ONLY. The previous moisture count will be stored. The D-ONLY command will erase at the end of the count cycle. M-ONLY follows a similar circumstance.

The tester will automatically take its own 4 minute standard count if STD and LOCK are pressed simultaneously. All four memories are erased and the standard count is fed into all four memories. See Section 1-2.01, Standard Counts.

The tester may be internally checked by pressing TEST and LOCK simultaneously. The tester will count for one minute, providing a fixed time base pulse to all four memories. All four memories should read 65536 at the end of the count period. (1/4 minute & 16384 after 6/78)

The LOCK key prevents an accidental field erasure of the standard count memories by an inadvertant pressing of the STD or TEST keys.

WARNING

Insure that the tester handle is placed in the safe position prior to placing the tester into the approved carrying case.

Upon completion of testing, store the tester away in its shipping case. There is no ON/OFF switch and today's last readings will still be available when the tester is next used. Remove batteries for storage more than one week.

1-1.04 SOURCE ACTUATION

The shutter is released by pulling back on the handle latch pin and pressing down on the handle.

The shutter is spring loaded and closes automatically when the handle is raised to the SAFE position.

The operator should insure proper latch or handle position by visually checking the latch pin for full forward location at the desired depth.

Lock the source rod when in storage by pushing in the lock button on the end of the rod. Key required to unlock handle.

After repeated tests the shutter mechanism will become dirty with accumulated soil pulled into the chamber on the end of the source rod. The shutter will jam or become sticky. (See paragraph 3-3.0 for shutter maintenance.)

DO NOT FORCE THE SOURCE ROD TO OPEN THE SHUTTER.

1-2.00 To Measure or Take a Test, General

The following operations are required to take a field test:

1-2.01 Take a Standard Count

1-2.02 Prepare the Site

1-2.03 Take a reading on the site

1-2.04 Determine Moisture and Density from the Calibration Curves or charts

1-2.05 Compute Percent Compaction

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WARNING

Insure that the tester handle is placed in the safe position prior to placing the tester into the approved carrying case.

1-2.06 Store the tester away

1-2.01 Standard Count

Nuclear tester performance is effected by the decay of the radioactive source, by aging of the electronic components, and by minor mechanical wear and tear. As with any measurement tool, it is necessary to check the tester against a reference standard periodically to insure continued accurate operation.

This is achieved with your tester by the taking of a Standard Count on the reference standard furnished with the tester. Variations in tester performance will effect the Standard Count in the same proportion as they will effect the field counts.

Should variations in tester performance occur, these variations will effect both the field and standard counts proportionately, thus the final ratio remains constant and the tester remains accurate. The standard count thus becomes a means of continual calibration correction for the nuclear tester.

A further benefit can be achieved from the standard count due to the statistically reliable nature of the decay of the radioactive source over short periods of counting. The following paragraphs describe methods of evaluating tester performance using inspection of a series of successive counts in a standard count series.

1-2.01.1 How to Take a Standard Count

There are two methods of taking a standard count. Both use the same mechanical setup. They differ only in the method of accumulating the final standard count result.

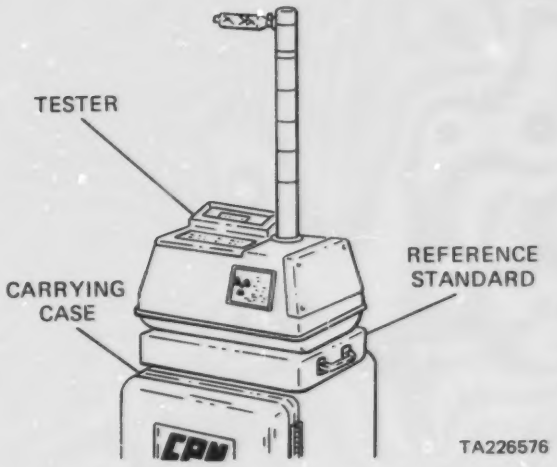

Figure 1-2. Reference Standard

NOTE

Handle in SAFE position Five foot clearance

Stand the shipping case on end and place the reference standard across the protective strips on the case. Three buttons on the reference standard fit into accommodating depressions in the bottom of the gauge. (See Figure 1-2)

Place the source rod in SAFE position and be sure the tester is at least five feet from nearby objects.

At this point two counting methods may be used:

Manual, with successive counts.

Automatic, with four minute averaging.

The Manual method is used for periodic tester evaluation per Paragraph 1-2.01.2.

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The Automatic method is used for routine daily standard count accumulation into the tester Standard Count Memories.

Manual method

Successively accumulate 10 1/4 minute counts.

Do NOT use other time periods for purposes of evaluating tester performance under this program.

Proceed to paragraph 1-2.01.2.

Automatic method

Press STD and LOCK simultaneously on the keyboard and the tester will now clear all four memories, and will count a 4 minute count into all four memories. The 4 minute count will be normalized to a 1/4 minute common base for ease of subsequent computations.

Record the final average of either method on the daily field work sheet. The 4 minute automatic standard count will be retained in memory until erased by the next STD or by the taking of a TEST count.

1-2.01.2 Tester Evaluation using Manual Std Count

Periodically, the tester should be checked for good statistical operation. This is the ONLY way the operator can verify that his tester is operating correctly. Using this technique it is possible to predict a future failure before it is severe enough to cause field errors or complete breakdown. This periodic evaluation should be performed at least once a month or whenever the tester has not been used for several months.

All nuclear method testers will vary in count rate from one undisturbed count to another due to the random nature of the radioactive source decay. This is a very reliable random rate in that it faithfully obeys the laws of statistics relative to random sources of "population". . . . . .where population = count rate for nuclear testers.

Given: Any series of numbers taken among a varying population of events will exhibit a form of standard deviation.

A series of nuclear tester counts, taken with the tester in an undisturbed position between all counts, will also exhibit a standard deviation around the average of the counts or mean.

Given: It is true that if the source of a series of events is truly random, then the standard deviation of the counts will equal the square root of the average count or mean.

Given: One standard deviation equals 68% of the population of events for a series.

Put these all together and:

± 1 Std Dev = $\pm \sqrt{\text{Average count}}$ = 68% Prob.

This finding can be put to good use in evaluating tester performance if we use it to inspect a series of counts taken in the standard count mode.

(The procedure may also be used to evaluate any series of nuclear tester counts. It is only necessary that the tester not be moved during the series of counts. Counts could be taken in any operating position, with another gauge nearby, etc, just do not move it during the series.)

Two evaluation methods will be described.

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One uses a hand calculator with statistic functions, the other uses a manual checkoff method. Both techniques work well. Both should be used with ten successive counts taken in the 1/4 minute time period. (This will not work if counts are taken in other time periods due to the averaging or normalizing of the tester on long time periods.)

1-2.01.3 Calculator Evaluation using Std Dev.

Enter the series of numbers into the calculator following calculator instructions for standard deviation. Determine the deviation and place it in one of the calculator's memories.

Pull up the mean of the series of counts and determine the square root of the mean.

Divide the deviation by the square root.

From the above discussion, if the series was "perfect", the square root would equal the deviation and the division would be "1.0". The series will seldom work out perfectly, however, and some variance from 1.0 will be observed. It is normal for this to lie between 0.75 and 1.25 with a general tendency towards 1.0 for a normal tester.

1-2.01.4 Manual Evaluation

Take the same series of ten numbers. Use 1/4 minute time key.

If the standard deviation of the series is to lie within $\pm\sqrt{\text{average}}$ and this is to include 68% of the series, then this is merely stating that 68% of the numbers should lie within $\pm\sqrt{\quad}$ of the average or mean and that 32% should be outside the average or mean.

That is, out of a series of ten numbers, 32% or about 3 out of 10 will lie outside plus or minus the square root of the average.

We simply add up a series of numbers, average them, determine the square root of the average and then add and subtract this square root to the average.

The resultant high and low limits will include 68% of the numbers in the series and 32% will be higher or lower than the limits.

The following example illustrates a typical tester placed in Standard Count configuration and using the Student Field Data Worksheet (DA Form 5448-R (Moisture and Density Tester Field Data Worksheet)), Figure 1-3, to accumulate the data for ten counts. DA Form 5448-R is located at the back of this TM for local reproduction authority. This tester was normal in all respects.

We seldom are fortunate enough to have the series work out exactly 3 out of 10 each time we run a series. However, if we make an intelligent allowance for variations in numbers we will observe that the series will exhibit a general trend towards 3 out of 10. An occasional 2 out of 10 will be observed and an occasional 4 out of 10 will be observed. However, the statistic probability of a 5 out of 10 or a 1 out of 10 is very slim, and such splits should be very rare for a normal tester.

It is important to observe the average from one such Standard Count Evaluation to another. If the average is within approximately 1/3 to 1/2 of the square root of the prior average, then the difference between the two series is normal.

It is most desireable that the operator maintain a standard count diary with his raw data and his computations written down. This is most helpful to the repair shop should the tester require repair for some complaint of "drift" or "erratic" counts. Use DA Form 5449-R (Moisture and Density

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DATE: _____

MOISTURE & DENSITY TESTER FIELD DATA WORKSHEET

SITE: _____

STANDARD COUNTS

DENSITY COUNTS (ADD ZERO)				MOISTURE COUNTS (ADD ZERO)			
6114		HIGH	6154	3198		HIGH	3157
6138		SqRt +	78	3186		SqRt +	56
6046		AVG	6076	3079		AVG	3101
6110		SqRt –	78	3072		SqRt –	56
5951		LOW	5998	2968		LOW	3045
6138				3185			
5992				3072			
6108				3151			
3989		√ AVG =	78	3034		√ AVG =	56
6178				3068			
60764		TOTAL StCt.		31013		TOTAL StCt.	
6076		AVG (÷ 10)		3101		AVG (÷ 10)	

A

A

B/S DENSITY TRANS. 2" TRANS. 4" TRANS. 6" TRANS. 8" B/S MOISTURE

TA 226570

Figure 1-3. Field Data Worksheet

Note that both standard count series produced a normal split of 4 out and 6 inside the limits of ± square root of the average. A split of 2 out/8 in or 4 out/6 in is normal occasionally, provided the usual split is a 3/7 and provided the average standard count remains within approximately 1/3 square root of the prior series' average.

Tester (Nuclear Method) Utilization Log)) to record standard counts. DA Form 5449-R is located at the back of this TM for local reproduction authority.

It is perfectly proper to use the Automatic Standard count for daily routine, but it is very desireable that the full evaluation be run periodically to ascertain that your tester is running properly, regardless of make or model.

1-2.01.5 What do Poor Results Mean?

If the tester consistently exhibits a tendency towards a high deviation, that is, the calculator method trends more towards the 1.25 end of the spread than the 0.75 end, and the manual method trends more towards 4 and 5 out instead of 2 out, the tester is indicating a tendency towards erratic counts beyond the normal projected deviation to be expected.

This erratic tendency is likely to come from a dirty high voltage supply, dirty detector connectors, or a failing component in the high voltage supply. Simply dusting off the supply may eliminate the problems.

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If the tester consistently exhibits a tendency towards a low deviation, that is more towards the 0.75 end for the calculator or more towards a 2 out or 1 out for the manual method, then the tester is picking up some periodic count rather than purely random count.

This smooth tendency is probably due to a failing filter network in some supply system which would allow a steady noise to creep into the system, a noise not subject to the variation of a random source.

Using either of these techniques, either calculator or manual evaluation, the operator can maintain a close watch on his tester and can be confident that his field work is accurate without electronic error or decay drift.

IT IS NOT ADEQUATE TO MERELY RUN THE AUTOMATIC STANDARD COUNT AND NOT RUN THE PERIODIC EVALUATION.

THE DAILY AUTOMATIC STANDARD COUNT WILL SERVE TO VERIFY GENERAL GOOD OPERATION, BUT IT WILL ALSO MASK MINOR VARIATIONS BETWEEN COUNTS THAT ARE INDICATORS OF POTENTIAL TESTER FAILURE.

THE STANDARD COUNT IN THE AUTOMATIC MODE CAN COVER UP ERRATIC TENDENCIES, NOISY DETECTOR, OR OTHER PROBLEMS. THE TESTER MAY APPEAR VERY NORMAL UNDER SUCH CONDITIONS.

WE MUST MAINTAIN A PROFESSIONAL ATTITUDE ABOUT OUR EQUIPMENT AND ITS OPERATION AT ALL TIMES.

THIS MEANS FREQUENT CHECKING OF CALIBRATION AND PERFORMANCE.

1-2.02 SITE PREPARATION

Tests will only be as good as the quality of site preparation. The site must be flat, free of voids, with surface irregularities filled with native fines or sand.

If transmission is used, the hole must be neat and square to the surface, and protected from puffing or movement during the drilling of the transmission hole or retraction of the drill pin.

It is desireable to rotate the tester 90° or more on rocky soils to obtain the largest sample size practicable. This avoids the possibility of a single rock skewing the results.

Site Selection

CPN advocates statistical testing wherein the average of several test sites is used to accept or disapprove the project. The nuclear tester is much faster than the older, conventional test methods and statistical programs may be employed.

Using the CPN Random Selection Cards, (See Appendix J) select five site locations and take one test on each location. Average the sites for a statistically valid evaluation of the project.

Each site must be free from major protuberances reasonably smooth, and should be representative of the overall project.

Preparation

Using the CPN Cast Aluminum Guideplate, smooth the surface, removing large stones or surface debris which would prevent the tester from sitting flat. Any technique of smoothing, pounding, or other flattening will be adequate. It is impossible for the operator to pound the site so hard as to compact the site. He can only flatten down the top 1/16" or so to provide a good surface.

Using a sieve, shake some native fines over the site to fill in any remaining air voids to remove possible errors from surface roughness. The tester must rest upon native promontories, however, with only the voids filled in. The tester must not rest upon a "cushion" of filler material.

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If the test site is asphaltic concrete, (AC), a coffee can "salt shaker" with fine sand may be used to fill in the voids.

The tester has a reduced bottom surface to provide the best possible seating under adverse conditions. This facilitates seating the tester on AC where a rubber tired roller has been used.

1-2.02.1 SEATING QUALITY EXPERIMENT

An experiment can be run to test the required effort to obtain good seating:

1. Take a backscatter reading prior to any work.

2. Perform a minimum of surface work, take another reading.

3. Perform more work, clearing, smoothing, etc, and take another reading.

   The readings will drop in count rate as the tester is seated better and better. When readings have ceased to change, the tester is seated as well as it can be. This is then an index of the work required to obtain good seating.

1-2.02.2 SURFACE ROUGHNESS ERROR

Surface roughness error is the error introduced into the tester readings due to the rough surface obtained during seating. Such error was exhibited in the work in Para 1-2.02.1.

The dual position tester backscatter feature provides a means of selecting a shallow backscatter position (AC Position) for best results on thin lift Asphaltic Concrete and a slightly deeper backscatter position (BS Position) for use on soils or thick Asphaltic Concrete.

Unfortunately, the thinner the tester attempts to read, the more sensitive it is to surface roughness. The following test will illustrate the potential roughness error and will permit the operator to use the tester to his best advantage with a minimum of error.

1. Take a reading in both normal backscatter (BS) and in the shallow backscatter (AC) on a smooth concrete surface. Use the 2 minute count period for this test.

2. Raise the tester the thickness of a dime, approximately 0.050-inch, producing a 100% void under the tester.

3. Repeat the readings in both AC and BS.

4. The tester will read approximately 3 PCF low in BS and will read approximately 7 pounds per cubic feet (PCF) low in Ac.

   This will vary slightly between testers of the same design and between testers of different manufacturers.

   The error is an index of the amount of effort required by the operator to obtain good seating with any specific gauge.

1-2.02.3 DEPTH OF READING (Figure 1-4.)

Certain physics limitations present themselves in depth of reading of nuclear testers.

No matter how the design of the tester is made, soil testers using GM tubes and radioactive gamma sources of approximately 0.7 MEV energy will not read more than 5-inches deep for 99% of their response in construction materials from 100 to 170 PCF.

If the radioactive source is well collimated as in the BS position, the tester will tend to pick up 90% of its returned radiation from approximately 2.5-inches deep.

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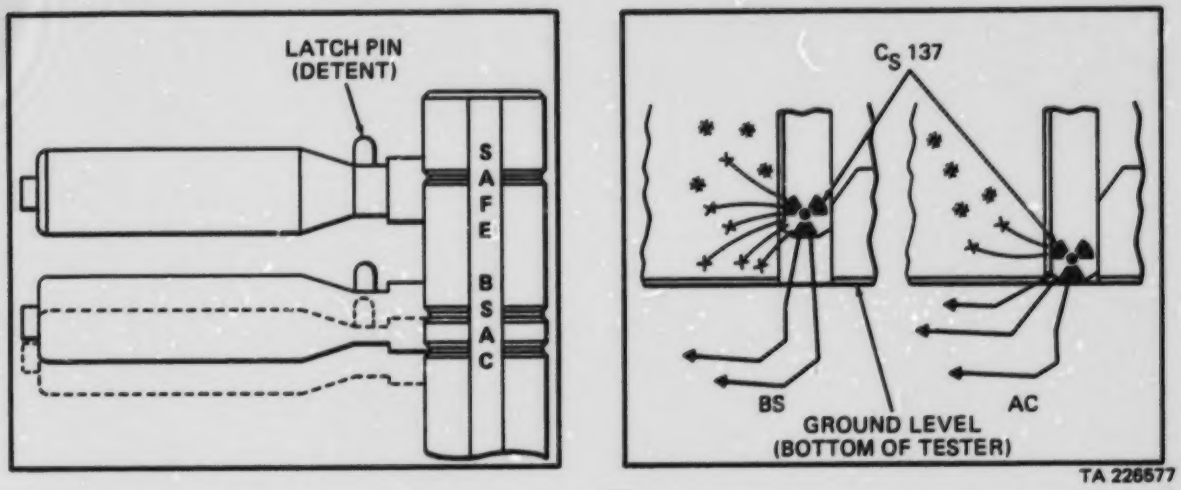

Figure 1-4. BS and AC Positions

NOTE

The tester's raised (collimated) BS position blocks shallow gamma rays to provide deeper reading for soils. Lower AC position permits utilization of shallow rays to decrease depth of effective reading for shallower materials. (Surface roughness effect increases with AC position, however, and site prep requires care.)

If the radioactive source is NOT collimated, the source being positioned at the bottom of the tester permitting gamma rays to stream at an angle backwards towards the detectors, the tester will pick up 90% of its returned radiation from approximately 1.5 - 1.75-inches deep.

Both positions will read the same overall depth for 99% of its returned radiation.

Thus, if the intention of the reading is to read a soil embankment of more than 2-inches thickness, then either BS or transmission should be used to insure the deepest possible reading.

If the density of a thin lift overlay is desired or any lift of less than 2-inches thickness, then it would be desireable to use the AC position and to place the additional surface seating care required in these shallow positions.

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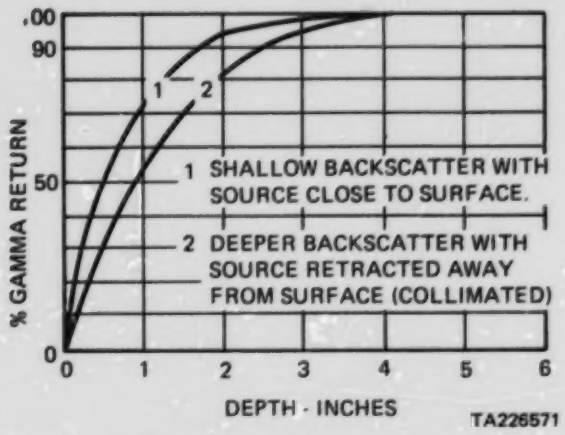

Figure 1-5. Effective Depth

1-2.02.4 TRANSMISSION ROUGHNESS ERROR

Transmission is inherently an accurate mode of measurement in all respects. It is a linear measurement with depth and is not fooled by varying densities near the soil surface and is comparatively immune to surface roughness problems.

Seating area requirements for the transmission mode comprise only a 2 x 6-inches wide surface under the GM tube, thus the tester can be used on very difficult surfaces where a backscatter tester would be impossible to use.

Transmission surface roughness error is approximately 1/10th that of the backscatter errors.

1-2.02.5 DRILL TRANSMISSION HOLE

The transmission hole must be vertical to the smoothed surface and must not be damaged in the process of drilling and retraction of the drill.

Place the Cast Guideplate on the surface and use the guide to support the drillpin. Hammer the drillpin into the ground, tap it lightly to loosen it, twist it to further loosen it, and pull it out of the ground. DO NOT USE THE CAST GUIDEPLATE AS A RETRACTION DEVICE. IT WILL DAMAGE THE TOP OF THE GUIDE HOLE.

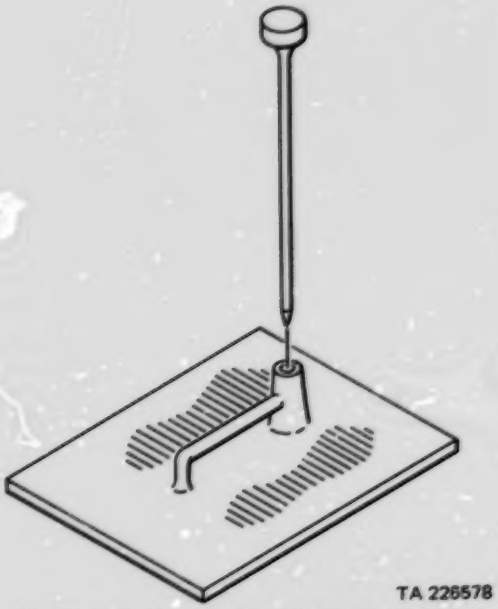

Figure 1-6. Transmission Hole

NOTE

During drilling and retraction the operator's weight on the guideplate confines the soil to prevent eruption or puffing.

The operator's weight on the plate confines the soil in drilling and in retraction to produce a neat, undamaged hole for the readings.

On heavily compacted material above 95%, cracks may appear in the soil. These will not effect the readings if the tester is placed so no crack extends from the source directly back to the detector tubes.

If the drillpin "walks away" as a result of striking a rock in the soil, try another location. If repeated tries cannot produce a satisfactory hole, then the test should be aborted.

1-2.02.6 SEATING THE TESTER IN TRANSMISSION

See Figure 1-7.

From a radiation exposure standpoint, it is undesireable to have to spend a great deal of time "playing" with the tester in seating it. Locating the hole for

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insertion of the source rod in transmission is frequently a problem and CPN has made this easy for the operator.

A small cast lip is on the front of the bottom casting to provide for insertion ease.

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Figure 1-7. Seating Transmission

NOTE

Align body safely above tester with eyes just peeking at source. Support weight on legs and gently lower in hole.

1. Bring the tester close to the hole.

2. With body over the tester, right elbow braced on right knee, and right hand lifting the lip, lower source until it is between 2 and 4-inches. Let go of source rod handle.

3. Grasp guidetube above handle and raise tester until source is visibly going into hole. (Peek over the front of the tester.)

4. Lower tester and then lower source into hole.

1-2.03 TAKE A READING ON SITE

Once the site is prepared, a standard count is available, and the tester seated, a field count can be obtained.

No advantage is gained from repeating a count on exactly the same site. It is permissible to rotate the tester 90° or more on a site to obtain two views of the location, but there is nothing to be gained from taking more than one count without at least moving the tester. It would be better to move the tester to another site nearby for the second count in order to obtain a better representative sample of the overall project.

Reviewing Paragraph 1-2.01.2 and applying these statistical factors to the tester readings, we will observe that:

1. The tester will not count exactly the same two times in a row except by coincidence.

2. This count variation is a function of the random source decay.

3. This will obviously produce a predictable error in the final result of PCF values.

4. The error, identified as "Precision" can be charted as follows: (1 minute counts)

			±PCF
BS Regular	@	120 PCF	.60
BS (AC)	@	120 PCF	.50
6" Trans	@	120 PCF	.25
Moisture	@	15 PCF	.25

This error is the tester's repeatibility. The final accuracy obtained on the site is also a function of how accurately the factory calibrated the tester and how carefully the operator chose and prepared his site.

The value of the final result is also a function of how representative of the overall project the selected site is.

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Precision is also influenced by the selection of time period on the Operations Touchkeys:

(in PCF)	1/4	1/2	1	2
BS	1.20	.85	.60	.42
AC	1.0	.71	.50	.35
6"	.50	.35	.25	.18
H20	.50	.35	.25	.18

Select the time touchkey which will produce the desired precision versus time available for the test.

1-2.03.1 FIELD COUNTS, MOISTURE, BS, AND AC

1. Site is prepared, std count recorded.
2. Seat tester firmly.
3. Release source handle trigger and lower source to BS or AC position as desired.
4. Press desired Operations Touchkey.

   Tester will commence slow "beep" during count.
5. Tester will "beep-beep" fast at end of count.

   Press DENSITY DATA or MOISTURE DATA key to read count from tester.

   Record this on the Field Data Worksheet.

NOTE

DA Form 5450-R (Moisture and Density Field Test Sheets) (an abbreviated version of DA Form 5448-R) can be found at the back of this TM.

Moisture is taken at all times during any density count. The moisture source is separately mounted within the tester. Only the density source is in the source rod. The moisture reading taken in the BS position is recorded on the worksheet.

6. If a density only or moisture only count is required, press the D-ONLY or M-ONLY keys to take only the desired count. The other prior count will be saved in memory.

1-2.03.2 FIELD COUNTS, TRANSMISSION AND MOISTURE

1. Site is prepared, std count recorded, hole drilled.
2. Seat tester over hole and insert source per Para 1-2.02.6.
3. Insure that handle is firmly in the desired depth slot.
4. Firmly pull tester back against the hole to seat the source against the hole wall.
5. Depress the desired time key. Both moisture and transmission density will be taken at once.
6. Record the data from DENSITY DATA and MOISTURE DATA displays.

1-2.04 DETERMINE DENSITY AND MOISTURE FROM CALIBRATION CHARTS

Paragraph 1-2.01 described the use of a ratio for determination of the final values, the ratio serving to cancel out long term drifts from source decay or component aging.

It is now necessary to record the field count data and to divide that data by the recorded standard count to obtain the desired ratios. The ratios will then be taken to the appropriate calibration charts to determine the final answers.

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Calibration charts are provided by the manufacturer (CPN) with the tester. The charts are identified with a serial number which matches the serial number of the tester. Charts and testers are not interchangeable.

RATIOS	DENSITIES
0.246	127.00
0.243	127.50
0.240	128.00
0.238	128.50
0.235	129.00
0.232	129.50

Figure 1-8.

NOTE

The ratios listed in the left column cross over to the densities listed on the right. For example, the ratio 0.240 crosses over to 128, which is the density in pounds per cubic foot weight (PCF). If the ratio was calculated to be 0.239, which is not listed, the ratio would then have to be rounded up or down (usually down) to the closest listed ratio so the density can be determined.

The following portion of DA Form 5448-R (Figure 1-9) provides data for a typical density test using a tester at three sites on a project and with three depths taken at each site. The average of the three readings will be used as the final evaluation density for the project.

The standard count is taken from Paragraph 1-2.01.4 Page 1-12.

$$\frac{\text{FIELD COUNTS}}{\text{STANDARD COUNT}} = \text{RATIO}$$

1-2.04.1 DETERMINE DRY WEIGHT

Subtract the moisture in PCF from the wet weight for each density depth to obtain a dry weight. The dry weight (DA Form 5448-R) is then used for determination of Percent Compaction and Moisture (See Figure 1-10).

1-2.05 COMPUTE PERCENT COMPACTION

The tester has now provided the actual, in place density and moisture obtained during compaction of the soil. Whether this is good enough for the project is not known until we compare this in place density with the optimum weight produced from a laboratory sample of the soil being tested (found in a Corps of Engineers handbook or determined by actual laboratory tests). This is the "Proctor" value. To obtain a Percent Compaction (DA Form 5448-R) we divide the dry density by the Proctor to obtain a value (see Figure 1-11).

$$\frac{\text{DRY WEIGHT}}{\text{OPTIMUM}} = \% \text{ COMPACTION}$$

1-2.05.1 COMPUTE PERCENT MOISTURE

Percent moisture is expressed as a percent of the dry weight in soil testing. Therefore we must divide the moisture in PCF by the dry weight in PCF to obtain percent moisture dry, DA Form 544-8R (see Figure 1-12).

$$\frac{\text{H2O IN PCF}}{\text{DRY WEIGHT}} = \% \text{ MOISTURE DRY}$$

1-2.06 COMPLETION OF TEST

Upon completion of the test it is only necessary to store the tester away. Remove batteries for storage more than one week.
It is not necessary to turn the tester off or perform other operations.

1-3.00 CALIBRATION CHARTS

CPN calibration curves or charts are determined from tests taken on CPN calibration standards.

CPN uses a variety of standards for tester calibration including natural standards and artificial (metal) standards. Unfortunately, there is no "National

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FIELD COUNTS	B/S DENSITY	TRANS. 2"	TRANS. 4"	TRANS. 6"	TRANS. 8"		B/S MOISTURE
	1470		8180				1236
	1463		8119				1237
	1448		8037				1242
TOTAL →	4381		24336				3715
AVG ÷ →	1460		8112			÷	1238
÷ by StCt. →	6076		6076				3101
RESULTANT RATIO	0.240		1.335				0.399
WET DEN PCF	128		127.5			H_2O PCF	14.0

Figure 1-9. B/S Density and Moisture, 4" Transmission

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DRY WEIGHT	(BS)	(2")	(4")	(6")	(8")
WET DEN PCF	128		127.5		
LESS H_2O	− 14		− 14		−
DRY DEN PCF	114		113.5		

TA 226573

Figure 1-10. Dry Density PFC

PERCENT COMPACTION						
DRY DEN PCF	÷	114		113.5		
* SOIL MAX DEN		130		130		
X 100 = %		87.7		87.3		

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Figure 1-11. Percent Compaction

PERCENT MOISTURE						
H_2O PCF	÷	14		14		
DRY DEN PCF		114		113.5		
X 100 = % MOISTURE		12.3		12.3		

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Figure 1-12. DA Form 5448–R (Percent Moisture)

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Bureau of Standards" standards in the nuclear soil testing industry. Each manufacturer does his best to provide an accurate set of standards and he checks these standards against other standards wherever possible. The major manufacturers generally agree quite closely on their standards although some disagreement may exist here and there with standards of users who have made them themselves.

If the chart produces results suspected of being in error (conflicts with field results of other testers or of other compaction measurements) do the following:

Check operation of tester, Para 1-2.01.

Check accuracy of other devices or tests.

Retest a prior site that was correct.

1-4.00 MOISTURE MEASUREMENT ERRORS

The moisture channel is actually a "hydrogen analyzer". It responds to moderated neutrons, the moderation largely a function of neutron collisions with hydrogen and only incidently a function of collision with the large nuclei of other atoms.

Thus, any source of hydrogen will result in moderated neutrons and the tester will attempt to respond accordingly.

This can be used to our advantage in deliberately measuring asphalt content where the only hydrogen that we would expect to "see" would be from the hydrocarbons in the AC and not from moisture.

However, the hydrogen analyzer aspect of the tester can also be to our detriment if the soil we are trying to measure has hydrogen from other than free water around the mineral particles.

Compaction is obtained by coating the surfaces of the soil particles with a thin, molecular film of water to provide lubrication during our compaction effort. This is the only moisture we wish to measure with the tester.

Unfortunately, however, some soils have other forms of water known as "bound water" or water of hydration, which bind themselves into the mineral matrix and become a part of the soil particle. This form of water does not contribute to the compactive effort, but is measured by the neutron channel in the soil tester.

A simple corrective technique can be used to cancel this error when detected.

The soil tester will always indicate a higher than actual moisture value when this error exists.

It will be adviseable to make periodic checks with conventional testing means to verify that the problem continues to exist in a given embankment.

An infrequent form of error is occasionally observed in desert countries where a high deposit of boron may result in absorption of the moderated neutrons producing a low moisture reading. This is highly unusual. A compensating calibration curve must be prepared using oven samples for this occurance.

1-4.01 MOISTURE REFLECTION ERRORS

Known as "trench wall effect", this error is the result of reflection of moderated neutrons from the surface of a nearby object to the tester, usually a trench wall or a backfill wall.

Knowledge of how the tester is constructed will minimize this error and a simple test can be conducted to determine the magnitude of this error in the soil tester.

The moisture detector is a long, 2-inches diameter tube lying along the long axis of the tester under the display area. Its most sensitive side is

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the side presented to the exterior of the tester on the display side.

The least sensitive area is the ends of the tube and the side of the tester facing the operator as he views the display.

It is proper procedure to place the tester so the broadside of the tube "looks down" the trench rather than at the wall.

Conversely, the geiger tube is located at the end of the tester furthest from the source and lies across that end. It would be best that this end be placed looking away from a wall for density tests.

Thus, good practice in a confined space would be to face the tester longitudinally in the direction of the trench for density testing and across the trench for moisture determination.

The operator can make a simple experiment with his nuclear tester to determine the effect of the wall reflection.

Set the tester in the center of a concrete floor, at least ten feet from nearby objects. Determine a moisture reading on that spot.

Fill a two cubic foot box with damp sand or soil and slowly move this box towards the tester on each of the four sides, about 6-inches at a time, taking readings each time. Note where the box is when the readings produce an error sufficient to cause an unacceptable field density conclusion.

This distance from the tester will differ on the four sides, and will differ between density and moisture.

In general, the tester can be used in a trench of not less than 18-inches span, preferably about 24-inches wide, for best results on moisture. The density readings can be taken with the tester nosed directly into the wall, but the geiger tube end must be kept at least six inches from the wall.

Conduct this experiment with your testers to determine your own limits in your shop.

1-5.00 ASPHALT CONTENT DETERMINATION

The tester's moisture channel is a hydrogen analyzer.

We can use this to good advantage by extending the use of the tester to become a good AC content tester for field use.

Some additional hardware is required

1. Metal pan, approximately 16 x 16 x 4.
2. Compaction plate. . . .5 x 5 1/2 with a rod welded to it and a sliding weight to slide on the rod and permit a controlled compaction effort on the plate.
3. Accurate scale to approximately 30 pounds.
4. Straight edge and a finely graduated metal ruler. . . C-clamp to clamp the ruler to the straight edge. The straight edge should be approximately twice as long as the pan's longest dimension.

Procedure

We must establish an initial calibration curve in the laboratory. After that, the same procedure is used in the field to establish the desired asphalt content value.

We are going to prepare a sample of asphaltic concrete at a specific weight each time. This weight will be selected at the outset and will be used for the

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initial calibration as well as for all subsequent field tests. This weight should be approximately 95% of optimum for the typical asphalt weights used in the user's locale. Round it off to a practical value for ease of preparation and calculations.

We are going to initially prepare a sample at a known density, evenly compacted in the pan in one inch thick layers. We will thereafter prepare the sample in the same one inch layers for all field work using the same technique exactly.

1. Measure the pan and determine precisely the volume in each inch for the bottom three inches. The fourth inch will merely become a catch basin for the light material that is compacted into the third inch.

   If we used a 16" square pan, then each inch would hold precisely 0.1481 cubic feet.

   We shall establish a density to be compacted in the pan each time. . . .let say this is 135 pounds/cubic feet, a value that is about 95% of optimum for the region that is going to use this test. It will vary, of course for different parts of the world.

   If our desired density is 135 PCF, and if each inch in the pan represents 0.1481 cubic feet then a one inch layer compacted to 135 PCF would actually weigh 19.99 pounds.

   135 PCF x 0.1481 CF = 19.993 pounds.

2. We shall measure out exactly 19.99 pounds of hot AC mix and dump this into the pan.

   We shall spread it around evenly and then we shall compact it down, using our sliding weight on the plate, to a depth of exactly one inch.

   A 1/16th inch error in height is equal to a 6% error in final compaction. . .an error of 8.1 PCF, something we will not accept for calibration work.

3. Compact a second and third lift in the same manner.

   Weigh the final pan of material and it should weigh exactly 3 x 19.99 = 59.97 # plus tare.

4. Set the pan atop the tester shipping case in the same manner as you would take a standard count. Remove the reference standard from the case.

5. Take several tester moisture readings on the compacted surface, revolving the tester 90° each time. Record the readings.

6. Run an extraction of a sample of the compacted material to determine asphalt content.

7. Plot the tester reading (in ratio) on the vertical axis of a calibration sheet similar to that used for the CPN moisture curve, and plot the asphalt content PERCENTAGE across the bottom.

   This curve is now an accurate asphalt content curve.

   Zero is obtained by compacting a bone dry sample of the material into the pan and taking a tester reading. It may not be possible to obtain 135 PCF dry

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material in the pan, however. Any error resultant from an inadequate compaction of the dry material will be negligible.

8. This curve is accurate as long as the same 135 PCF is produced in the field. If other weights are desired for field compaction, then a separate curve should be produced for each desired field weight. Obviously, it is desireable to attempt to select only one or two appropriate field weights to minimize curves and effort.

The pan can also be set on legs, anything at least two feet from the ground and five feet from surrounding objects. Watch out for the tailgate of a pickup truck due to the presence of the gasoline tank and spare tire, both heavy in hydrogen.

1-6.00 ROOF MOISTURE TESTING

The soil tester becomes a most useful tool when it is used to measure the trapped moisture in a built-up roof. It is always difficult to locate a leak and to estimate the area of roof damaged by a leak.

Built-up roofs generally consist of a waterproof membrane sandwiching a thick layer of insulation between it and the roof structure. If moisture becomes trapped in the insulation, the insulating value is damaged and the roof structure is subject to deterioration, dry rot, or other injury.

Any attempt to puncture the roof to investigate the degree of moisture intrusion is undesireable because of the additional damage the testing introduces. The non-destructive nature of the tester provides for rapid, accurate determination of roof moisture without penetration of the roof.

1-6.01 ROOF MOISTURE IS A RELATIVE MEASUREMENT

All roofs are not constructed alike. They vary in thickness, type of insulation, type of underlying construction, and type of waterproof membrane. Some will have hydrocarbons associated with the construction materials and insulation, others will have little internal hydrocarbon structure. The neutron measurement channel is effected by the internal hydrogen in the same manner as it is with bound water in soil. Thus, a certain background reading will be present even though the roof is "dry".

A roof with wet insulation 4-inches thick will provide a higher moisture count rate than will a roof with the same wet insulation, but only 2-inches thick. Thus, the reading of a moisture tester on a single location on a roof cannot be used alone as an index of whether the roof is wet or dry.

A series of readings over a representative sample of the roof must be taken and readings compared to each other to produce a profile which can then be interpreted as a moisture profile.

1-6.02 PROCEDURE

Starting from a corner, take readings on a 10' grid pattern over the roof. 1/2 minute readings should be quite adequate. Record the actual nuclear counts. Do not bother with computing a ratio and do not attempt to use the soil moisture chart to determine actual moisture in engineering units.

It will be noted that a majority of the readings will fall at some minimum value for this particular roof. This will correspond to the dry readings. Other readings will be higher. The highest readings should be further explored with additional readings taken on 5' grid to establish the boundaries of the higher readings.

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These highest readings represent the wettest portion of the roof. It may be necessary to make a test penetration to determine the actual moisture present at this highest value. By observation this can be classified as an arbitrary "moist", "wet", or "saturated" value.

Readings in between the dry bottom readings and the moist high readings can be classified proportionately.

Extra readings should be taken around chimneys, vents, stairwells, cornices, and other protuberances. Wet areas should be tracked to their perimeters.

1-6.03 PLOT ROOF MOISTURE PROFILE

On a drawing of the roof, plot the observed values as dry, moist, wet, and saturated for each test location.

Draw "contour" lines between the values to enclose each given value area. A moisture pattern is immediately apparent.

For additional clarity, color the enclosed areas with a specific color pencil to designate the various moisture values.

Intelligent action can now be taken as to where repairs should be commenced on the roof and over what area. It may be obvious where the moisture is coming from. . .flashing, a previously unobserved puncture, crack, or low spot, once the pattern is drawn.

1-6.04 RADIATION SAFETY

Density is not a factor on the roof, therefore the shutter will be kept closed and gamma radiation beneath the tester is negligible.

A typical industrial built-up roof will be more than 8' above head height of occupants of space beneath the roof. Neutron radiation at that distance is less than 0.025 mrem/hr. Since the tester is constantly being moved from test spot to test spot, there is no radiation danger presented to occupants of the building during testing and no special provisions should be taken for safety.

The operator will take many readings in a day, however, and good practice dictates stepping back from the tester 5' or more while the tester is counting.

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SECTION II

RADIATION INFORMATION

WARNING

Always wear your beta-gamma badge when operating the tester and upon entering tester storage areas, and at other times as directed by the Local Radiation Protection Officer (LRPO).

NOTE

There is no danger to the Army Community and the general public when the tester is used, transported, stored, serviced and leak tested according to Section IV of this manual. Normal radiation exposure from a properly operating tester is far less than the maximum allowed dosage of 1.25 rem per calendar quarter, on an accumulated calendar year dosage of 5 rem.

2-2.1 GOOD RADIATION PRACTICES

a. Always keep in mind how close you are to the tester when it is operating. Distance from the tester is your best precaution.

(1) At any given distance, no matter how far or how close to the tester, when that distance is doubled going away from the tester, radiation exposure gets four times weaker.

(2) At any given distance, no matter how far or how close to the tester, when that distance is cut in half going toward the tester, radiation gets four times stronger.

(3) Always stand at least 5 feet away from the tester when it is operating.

(4) Complete taking measurements as quickly as possible.

(5) You are authorized to carry the tester only by its handle or in its carrying case. In either instance, the handle must be locked in the SAFE position.

b. A busy workday can result in as many as 30 measurements. A busy workweek could result in 5 days of extensive measurements.

(1) Even with extensive use, the dose to be expected from a properly operating and used tester is only 1/400 of the maximum allowed dose.

(2) Thirty (30) measurements per day times 10 seconds per measurement equals 300 seconds or 5 minutes per day of exposure at 2 feet from the tester.

(3) Five (5) days times 5 minutes equals 25 minutes, rounded off to 30 minutes.

(4) One-half hour times 1/2 mrem/hr equals only 1/4 mrem exposure during a busy workweek.

(5) Operators are allowed an average weekly dosage of 100 mrem.

(6) Keep the curious away when you are on the job, but don't frighten people by making it a big thing.

(7) Always place the handle in the SAFE position when the tester is not in use.

(8) Store the tester under lock and key when not in use. Only radiation protection officers and operators shall have access to tester and carrying case keys.

(9) Make it a habit to routinely wear your beta-gamma film badge. Store the badge at an approved location.

(10) Do not intentionally expose the Cs 137 source to air by extending it out of the tester in the 2, 4, 6 or 8-inch transmission positions. Do not withdraw the source from the measurement site before returning the handle from the SAFE position.

(11) Work fast and keep proper distance from the tester.

COMMON RADIATION TERMS AND VALUES

Radiation is similar to light. It increases in intensity by a factor of FOUR each time the distance from the source is cut in HALF.

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The radiation level drops by a factor of FOUR each time you move TWICE as far away from the source.

Certain terms are used to describe radiation factors important to tester users. Be familiar with the following terms and values:

CURIE: A term used to describe the size of a radioactive source. It represents a quantity of material disintegrating at the rate of 3.7×10^{10} disintegrations per second, or the same rate as one gram of Radium. This is not an index of how dangerous the source might be, but only an index of quantity of the material in question.

MILLICURIE: One thousandth (1/1000) of a curie.

MICROCURIE: One millionth (1/1,000,000) of a curie.

ROENTGEN: A term describing the amount of radiation accumulated, or dose, or exposure. A roentgen of radiation could be accumulated by standing near a large radioactive, unshielded source for a short time or near a small, unshielded source for a long time.

REM (rem): This is a better term for measuring human exposure accumulation than Roentgen because it has been corrected to provide a common base for radiation effects on people. Some radiation is highly penetrating and would be more potentially dangerous than other forms. The descriptions become equal when they are all corrected to the common rem base.

MILLIREM (mrem): One thousandth (1/1000) of a rem. Tester radiation levels are commonly measured in these very small units.

MILLIREM/HOUR (mrem/hr): A term used to describe the "brightness" of a radioactive gamma source. It is the strength of the radiation field at the point of measurement. This term is similar to foot-candles of light when discussing light.

The brightness of the radiation field will be dictated by the type of radioactive material involved, the size of the source, the amount of shielding present, and the distance from the source. The total amount of radiation accumulated would then become a factor of how much time was spent in the field.

NOTE

Since the tester uses small, well shielded sources, operators will be involved with only millirems of radiation and with levels which are only in the mrem/hr range.

100 mrem: Weekly allowed dose (5 rem/yr is max annual work dose).

5 mrem/hr: Average radiation dose at tester surface.

1/2 mrem/hr: Average gamma dose at 2' from tester (arm's length).

1/3 mrem/hr: Average neutron dose at 3' from tester (source to midtrunk distance when carrying tester).

1/2 mrem: Average heavy workweek accumulation of radiation for a tester user (1/200th of allowed dose).

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SECTION III

OPERATOR MAINTENANCE PROCEDURES

THIS SECTION APPLIES TO BASIC MAINTENANCE TO BE PERFORMED BY THE FIELD OPERATOR WITH A MINIMUM OF TOOLS AND EQUIPMENT AND WITH A MINIMUM ELECTRONICS KNOWLEDGE.

MAINTENANCE COVERED BY SECTION III INVOLVES ONLY THE USE OF A VOLTMETER AND COMMON HAND TOOLS.

REPORT ANY DEFECTS WITH THE TESTER TO THE LRPO.

WARNING

Do not attempt tester repairs. A faulty tester must be returned to a designated manufacturer's repair facility.

3-1.00 GENERAL

The tester requires little maintenance other than an occasional cleaning of the shutter and replacement of batteries.

Service problems will occur in three areas:

1. Batteries
2. Mechanical jamming of shutter... needs cleaning.
3. Electronic parts failure.

CPN testers minimize service problems in these three areas by careful design:

1. Batteries are replaceable with NICAD batteries, NSN 6140-00-497-0490.
2. The shutter mechanism uses a quick-release cleanout plate for ease of cleaning.
3. Electronics use CMOS circuits for long life and low current drain.

3-2.00 BATTERIES

The tester uses NICAD rechargeable 4 Ampere Hour D Size cells as standard batteries.

Due to excessive damage caused by battery leakage, only NICAD batteries, NSN 6140-00-497-0490, will be used as replacement. Quantity of eight (8) each should be ordered.

3-2.1. CHARGING (Figure 3-1.)

CHARGE NICAD BATTERIES ONLY. DO NOT USE ALKALINE OR ZINC-CARBON CELLS!

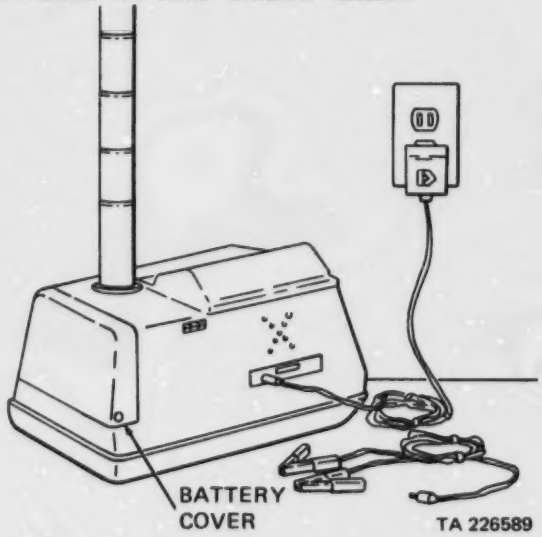

Figure 3-1. Charging

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NOTE

Optional 12 VDC Cord illustrated.

Plug the wall charger into 110/60HZ supply and plug the charger plug into the charger terminal on the tester. The tester will automatically charge with no danger of overcharging.

CPN recommends charging over a weekend or over night whenever the "L" low battery indicator is on.

NICADS lose approximately 1% of their charge per day through self-discharge. The tester will require charging if it has been in storage for a period of months.

Remove the batteries if the tester is to be stored for a period of more than a week.

3-2.2. ANTICIPATED TESTS PER CHARGE

Current consumption is low due to use of CMOS circuitry. The total time between charges will be a function of the number of tests taken and the total time passage between charges.

A tester uses approximately 80 milliamperes during count periods. It uses approximately 2 ma during quiescent periods (no counting).

The NICADS have a 4,000 milliampere charge life when new and fully charged. (4.0 Ampere hours).

Thus, if the tester was not used during a charge period, the tester should operate approximately 2,000 hours per charge or approximately 83 days.

If the tester is used continuously with no rest, it would last approximately 50 hours and would provide 3000 one minute tests (50 x 60).

How long it will last for a given user and how many tests will be available, is thus a combination of passage of time and tests performed.

The charge should last for many weeks for a typical user.

3-2.3. TESTING BATTERIES (Figure 3-2.)

Provision is made in the soil tester for checking cells under operating load. Test points are provided at the front lip of the battery pack holder for checking individual cells in the tester while under operating load.

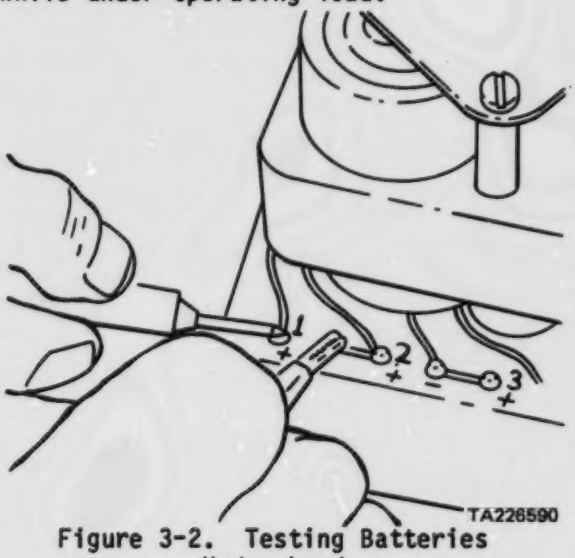

Figure 3-2. Testing Batteries Under Load

NOTE

Observe polarity of individual cell test points on front of battery pack.

Remove the front battery cover.

Using a DC voltmeter on a low range, check each individual cell while the tester has been counting for a lengthy period. Place the tester on standard count to obtain a lengthy load cycle.

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Keep repeating the count cycle command while checking the cells, that is, keep the tester running.

DC VOLTAGE MEASUREMENT

TYPE OF CELL	FULL CHARGE	5% CHARGE	DISCHARGE
NICAD	1.30	1.1	1.0

3-2.4 BATTERY REPLACEMENT (Figure 3-3.)

Remove battery cover.

Remove the knurled nut retaining the battery pack in the tester.

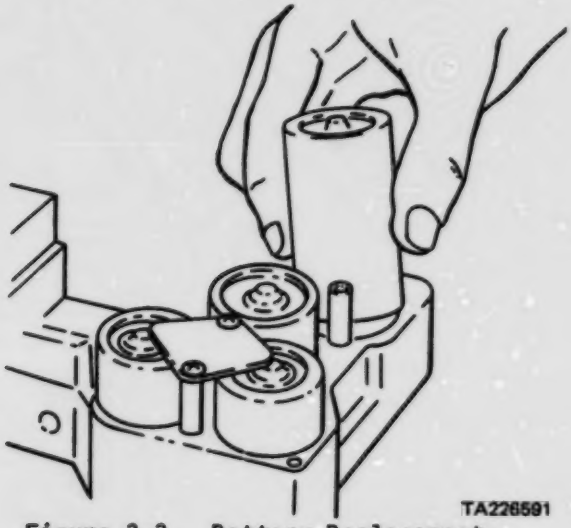

Figure 3-3. Battery Replacement

Slide the battery pack out of the tester.

Remove the appropriate hold down plate atop the cell that is to be replaced.

Replace the cell with positive end (button end) UP.

Replace the hold down plate, replace the pack, and replace the battery cover.

3-3.0 SHUTTER MAINTENANCE (Figure 3-4.)

The shutter is a carbide-tungsten-lead combination for maximum shielding and maximum longevity.

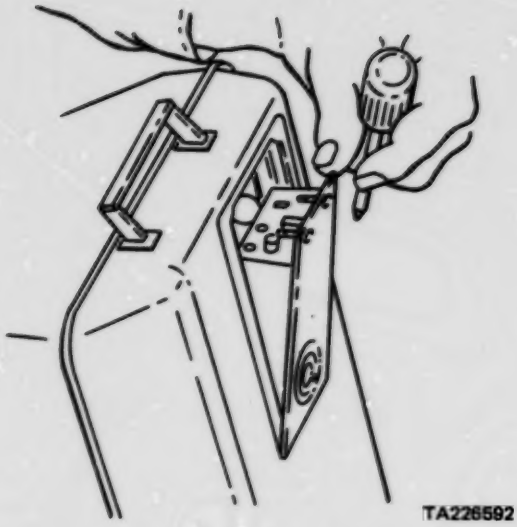

Figure 3-4. Shutter Maintenance

NOTE

Two 6-32 fasteners simplify plate removal.

It will require occasional cleaning due to dirt buildup within the shutter chamber.

Set the tester on its side or tail with the source in SAFE position.

Remove the 1/4 turn fasteners holding the cleanout plate in position.

Remove the plate and the captive shutter. The shutter and cleanout plate are an integral assembly.

Clean the shutter and the plate thoroughly, and clean out the shutter chamber with a brush (standing behind the tester while this is done). It is not necessary to extend the source to clean the end of the rod! Leave it alone!

Spray the shutter, cleanout plate, and the interior of the chamber with molybdenum-disulphide lubricant (Appendix E, Item 2). This lubricant should then be allowed to dry for a period of four hours or more to cure to the metal. This will provide a long life lubrication of the shutter for maximum utility between cleanings.

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DO NOT FORCE THE SOURCE ROD HANDLE WHEN THE SHUTTER IS DIRTY.

CPN does not recommend the use of oil or grease for lubrication, however, several customers have reported good performance by spraying WD-40 (Appendix E, Item 3) into the shutter chamber without disassembling it. The use of WD-40 will not injure the tester or effect test results. If it works for you, use it.

3-4.0 SHIPPING CASE MAINTENANCE

The shipping case is a fiberglass case built to MIL Spec standards. It is very strong and will produce excellent service.

No special care is required on the case other than an occasional cleaning (both inside and out) with soap and water.

3-5.0 TESTER EXTERIOR MAINTENANCE

Wash the tester with soap and water if it becomes unusually dirty.

WARNING

Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well ventilated area. Avoid contact with skin, eyes, and clothes, and don't breathe vapors. Do not use near open flame or excessive heat. The flash point for Type #1 Drycleaning Solvent is 100°F (38°C) and for Type #2 is 138°F (50°C). If you become dizzy while using cleaning solvent, get fresh air immediately and get medical aid. If contact with eyes is made, flush your eyes with water and get medical aid immediately.
If contact with eyes is made, wash your eyes with water and get medical aid immediately.

Remove asphalt with a mineral solvent.

Do not scratch the display window with abrasive cleaners.

If a major accident damages the tester by puncturing, refer to paragraph 4-7.3.

3-6.0. DIAGNOSTIC QUESTIONS

1. Does the display work? Are the display screws (4) tightened properly.
   On all channels?
2. Does the tester beep during counting?
3. Does the tester count in TEST MODE?

   What does it indicate upon completion?
4. Does it count in STANDARD MODE?

   Is this a normal standard count?

   What is the spread of the standard count? Refer to Paragraph 1-2.01 of OPERATING SECTION.
5. Does it count in the field count conditions?

   In all time sequences?
6. If possible, have a sequence of ten or twenty 1/4 minute counts available for reading over the phone to our serviceman.
7. How long has the problem existed? If intermittent, describe when it occurs as opposed to when it does not occur.

3-6.1 REPLACEMENT OF FUSE

The fuse is on the battery pack assembly.

A spare is also supplied on the assembly.

Replace fuses with the same size as removed, 1.5 Amp Slo-blo.

Repeated fuse blowing indicates internal electronic trouble.

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SECTION IV

SAFETY PROCEDURES

GENERAL

4-1.1. Purpose. This section provides life cycle controls for the Campbell Pacific Nuclear Model MC-1 Nuclear Method Tester, NSN 6635-01- 030-6896. Areas of responsibility are identified and assigned for personnel involved in the life cycle program.

4-1.2. Scope. These safety procedures apply to Active Army, US ARMY Reserve, Army National Guard, and all other installations, activities and units covered under the conditions of the Nuclear Regulatory Commission (NRC) license issued to the US Army Tank-Automotive Command (TACOM). Areas of involvement include procurement, storage, possession, shipment, transfer, operation, use and disposition of the tester.

4-1.3. License. NRC license number 21-01222-05 has been issued to TACOM. This license authorizes TACOM to purchase, use, and store the tester. Conditions of the license permit the tester to be issued throughout the Army without specific licenses being issued to individual users. The license also states how radioactive material shall be used to measure the moisture content and density of soils and asphalt. A copy of the license is furnished with each tester. Additional copies of the license may be obtained from the Commander, TACOM, ATTN: AMSTA-CZ.

4-1.4. Regulations. Refer to appendix A for applicable Army regulations (AR), technical bulletins (TB) and codes of Federal regulations.

RESPONSIBILITY

4-2.1. Program Manager. The Commander, TACOM, is the program manager. Areas of responsibility are:

a. Ensure compliance with Section IV of this manual by monitoring reports of radiation leakage tests, incidents and equipment improvement. Utilize feedback reports from logistic assistance teams, inspection teams and reports from major Army command radiation material control points (RMCP).

b. Maintain overall national inventory control point (NICP) functions by managing the tester as a major item.

c. Provide coordination for tester disposal in accordance with AR 385-11.

4-2.2. NICP Item Manager. Areas of responsibility are:

a. Account for each tester by serial number.

b. Issue testers to specific units, based upon plans developed individually, or together, by the Chief of Engineers and the Commander, TRADOC.

c. Ensure that the consignee for the initial issue of the tester is the commander of the specific unit (see b above). Under no circumstances shall the consignee be the property book officer (PBO), director of industrial operations (DIO), or the transportation officer (TO).

d. Ensure that all requests are channeled through the using command's RMCP, and that the requests contain a certification statement that the using command has a qualified Local Radiation Protection Officer (LRPO).

e. Issue disposition instructions and coordinate disposal action in accordance with AR 385-11.

4-2.3. Commander of Major Command. Areas of responsibility are:

a. Ensure compliance with applicable regulations and Section IV of this manual.

b. Establish at least one RMCP at the command level in accordance with AR 385-11.

c. Appoint a radiological control officer (RCO) for each RMCP. Forward two copies of the appointee's orders and qualifications to the Commander, TACOM,

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ATTN: AMSTA-CZ. Ensure that the RCO is well informed concerning applicable regulations and Section IV of this manual (see app A).

d. Ensure that each installation and activity that uses the tester has an effective radiation protection program.

e. Ensure the implementation of Title 10, Code of Federal Regulations (CFR), parts 19, 20, and 21.

4-2.4. Radiation Control Officer (RCO). Areas of responsibility are:

a. Review and approve the qualifications of the local radiation protection officer (LRPO) and the alternate local radiation protection officer (ALRPO). Forward a list of LRPOs and ALRPOs, and their qualifications for approval and certification, to the Commander, TACOM, ATTN: AMSTA-CZ. Any changes to the list shall also be provided to AMSTA-CZ.

b. When a qualified LRPO or ALRPO is not available, the RCO shall implement one of the following options:

(1) Suspend requisition for the tester.

(2) Suspend use of the tester until a qualified operator and LRPO are available.

(3) Transfer the tester to an installation or activity having qualified personnel. Notify the NICP item manager of the transfer.

c. Maintain records in accordance with AR 385-11.

d. Ensure that the tester is properly handled, as specified in the operator's manual, applicable regulations and Section IV of this manual. Periodically inspect and audit the records of installation and activities that have the tester.

e. Ensure that radiation incident reports are submitted by electrical means to the Commander, TACOM, ATTN: AMSTA-CZ, not later than 24 hours after the incident has occurred.

4-2.5. Using Unit Commander (UC). Areas of responsibility are:

a. Supervise implementation of the local radiation safety program in accordance with Federal and Army regulations.

b. Ensure compliance with appropriate instructions, regulations and Section IV of this manual.

c. In writing, designate the LRPO and ALRPO. Forward a copy to the RCO. The LRPO and ALRPO shall be specialists, non-commissioned officers or civilians who have completed one or more of the following courses:

(1) Radiological Safety Course 7K-F3, US Army Chemical School.

(2) A minimum of 80 hours formal training consisting of:

(a) Principles and practices of radiation protection.

(b) Biological effects of radiation.

(c) Radiac instrumentation and monitoring techniques.

(d) Mathematics and calculations that are basic to the use and measurement of radioactivity.

(e) Operation and use of the tester (CPN Model MC-1).

d. Establish a standard operating procedure (SOP) for use by using unit personnel that has been coordinated with the LRPO and RCO.

e. Assign the LRPO to perform leak tests, radiation surveys to ensure the tester is used only by trained personnel, and to prepare and submit necessary reports in accordance with Army and Federal regulations.

f. Notify the Commander, TACOM, of any radiation safety defects or hazards associated with the tester, and other actions that do not comply with Title 10, Code of Federal Regulations, Part 21.

g. Requisition the tester from the NICP item manager in accordance with AR 385-11.

h. Obtain prior approval from both the RCO and the NICP when transferring the tester from one unit to another, even within the same command, and when requesting disposal instructions. Units in Europe shall also obtain prior approval from the Radiological Control Office,

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Europe, when transferring the tester between units.

i. Notify the RCO, in writing, of any changes in LRPO and ALRPO assignments.

4-2.6. Local Radiation Protection Officer (LRPO). Areas of responsibility are:

a. Advise the unit commander on all radiation matters and ensure that all testers under the commander's jurisdiction are properly used and stored.

b. Instruct personnel in subjects relating to safe work practices, emergency procedures, the harmful effects of radiation overexposure, and other required topics in accordance with 10 CFR 19 and 29 CFR 1910.

c. Write and update the SOP for the unit's radiation protection program. The SOP shall include the tester.

d. Report any radiation incident, accident or theft to the Commander, TACOM, ATTN: AMSTA-CZ, by the most expeditious methods available; i.e., telephone and teletype. Then, make the same report, through channels, to the Surgeon General. Thefts shall also be reported to the NRC by the Commander, TACOM, ATTN: AMSTA-CZ. NRC regional office telephone numbers are provided in NRC Form 3 which is part of AR 385-11. Information copies of reports shall be provided to all intermediate headquarters.

e. Perform radiation leak tests in accordance with the procedure provided in paragraph 4-6.4. Leak test results shall include the LRPOs name and telephone number, and the tester serial number.

f. Upon receipt of the tester, conduct the initial radiation survey of the storage area and surroundings. Make certain that a copy of the NRC license and other documents required by 4-4.3a are appropriately posted at the outside entrance to the storage enclosure. A copy of the initial radiation survey shall be sent to the Commander, TACOM, ATTN: AMSTA-CZ. Periodic surveys conducted on at least a quarterly basis shall be recorded locally. Whenever a change in storage conditions occur, a copy of the survey shall be sent to the Commander, TACOM, ATTN: AMSTA-CZ.

g. Ensure correct shipment of radioactive items, both to and from the unit. See section V.

h. Review photodosimetry records maintained by the medical facility in accordance with AR 40-14.

i. As directed by 10 CFR 20 and in accordance with AR 40-14, limit radiation exposure to as low a level as can be reasonably achieved. Ensure that an ALRPO has been appointed, and that unit personnel comply with radiation standards.

j. Notify the UC and Commander, TACOM, ATTN: AMSTA-CZ of any radiation safety defects or hazards associated with the tester, and with any other actions or circumstances that do not comply with 10 CFR 21.

k. Ensure that records are maintained for each tester in accordance with AR 385-11.

l. Ensure that all radiation survey instruments used for monitoring the tester are calibrated in accordance with TB 43-180.

m. Be knowledgeable of the subject matter in this manual.

4-2.7. Alternate Local Radiation Protection Officer (ALRPO). The ALRPO shall assist the LRPO as required.

4-2.8. Operator. Areas of responsibility are:

a. Upon initial assignment, all operators shall be checked out by the LRPO to ensure that they can safely and correctly handle and operate the tester. Tester operators and their assistants shall have attended and successfully completed a course on the care, maintenance, and operation of the tester. Training courses shall include one of the following:

(1) Material Quality Specialist Course, US Army Engineer School. By agreement with the school, it is possible to attend the three-day portion of the course that is related to operating the tester.

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(2) Tester Training Course. The course is taught by an instructor who has been certified by the New Equipment Training School, TACOM Maintenance Directorate.

(3) Tester Training Course. This course is taught by instructors from the Technical Assistance Branch, TACOM Maintenance Directorate.

b. Maintain the tester user's log. A copy of DA Form 5449 can be found at the back of this manual.

c. The tester is under the control of the operator at the job site. The operator shall not leave the job site until the tester is secured and locked in its storage case. The operator shall then ensure that the tester is returned to its proper storage area.

d. Secure the tester when it is not in use. Ensure that the tester is not used when there is no LRPO/ALRPO assigned to the unit.

e. Be knowledgeable of the subject matter in this manual. Supplemental operating, maintenance, and repair parts instructions are included in Section V of this manual.

f. Notify the LRPO of any radiation safety defects or hazards that are associated with the tester.

g. Wear a beta-gamma type film badge when operating the tester, when in the storage area for the tester, and at other times as directed by the LRPO.

4-2.9. Tester Disposal. Notify the NICP item manager and the RMCP when testers are unserviceable, or are in excess of the amount required by the unit.

WARNING

Under no circumstances shall the testers be conveyed to a property disposal officer. All Disposal actions shall be conducted in accordance with AR 385-11.

PERSONNEL DOSIMETRY

4-3.1. Radiacmeters. All personnel who enter radioactive storage areas or operate the tester are authorized to wear IM-9E/PD Radiacmeters, NSN 6665-00-243-8199, if required by the LRPO.

4-3.2. Film Badges. All personnel who enter radioactive storage areas or operate the tester, or at other times as directed by the LRPO, shall wear beta-gamma type film badges. The Surgeon General has determined that neutron film badges need not be worn by personnel using the tester.

4-3.3. Medical Records. The responsibility for preparing and maintaining DA Form 3484 (Photodosimetry Report), is a function of each unit which uses the tester.

a. The person responsible for maintaining personnel dosimetry records shall be so designated in writing (AR 40-14) as the custodian of medical records. The custodian shall maintain DD Form 1141 (Record of Occupational Exposure to Ionization Radiation), and DD Form 1952 (Film Badge Application and Record of Occupational Radiation Exposure).

b. Personnel can obtain the total amount of radiation to which they have been exposed, and other related data, by contacting either their LRPO, the custodian of medical records, or the Chief, US Army Ionizing Radiation Dosimetry Center, ATTN: AMXTM-CE-DC, Lexington, KY 40511.

STORAGE

4-4.1. Unoccupied Areas.

a. It is mandatory that the testers be stored in locked, unoccupied and isolated areas. Fire resistant structures which provide protection from the weather shall be used when they are available. Only work that is necessary for

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normal storage and maintenance procedures shall be performed in these storage areas.

b. Tables of Allowance (TA) 50-914, Individual Safety and Protective Clothing and Equipment, authorizes one AN/PDR-27 Radiac Set for each work group requiring the protection of radiation monitoring.

c. An instrument survey, using the AN/PDR-27 or equivalent, shall be performed before the tester is placed in a storage area. This is done to determine background radiation level of the storage area, thus providing a measurement baseline in the event of contamination.

d. An instrument survey of the area surrounding any new storage facility shall be made immediately after radioactive material has been placed in the storage facility. The survey shall be recorded, and shall contain the information which is detailed in paragraph 4-6.1.

e. Maximum dose equivalence rate within the storage area shall not exceed 2.5 millirems per hour (mrem/hr).

4-4.2. Occupied Areas.

a. The number of testers that can be safely stored, in either occupied buildings or in occupied areas, is determined by shielding, the distance from the source and that part of the area which is occupied. Maximum dose equivalence rates outside of storage areas that are within occupied buildings and occupied areas shall not exceed 0.25 mrem/hr.

b. A tester which has been packed in its approved carrying case may be stored in a supply area or weapon storage area, providing the following requirements have been met:

(1) The cased tester shall be locked in a metal storage cabinet.

(2) The storage cabinet shall be isolated and located as far as possible from personnel work stations.

(3) All required radiation warning signs shall be displayed on the storage cabinet and on the door leading into the storage area.

(4) Floor markings shall be so placed as to identify a 2-meter area around the storage cabinet.

c. An instrument survey shall be performed in accordance with paragraph 4-6.1.

4-4.3. Administration.

a. Standard radiation warning signs, as described in AR 385-30 and AR-700-64, shall be conspicuously posted in places where radiation is present. A sufficient number of signs shall be posted so that they are clearly visible from all approaches to the area. The following documents shall be posted at the storage area entrance:

(1) NRC Form 3.

(2) 10 CFR 19, 20, 21.

(3) Section 206, Energy Reorganization Act of 1974 (Public Law 93-438).

(4) A copy of the NRC license.

(5) Radiation protection program SOP.

Copies of these documents can be obtained from the Commander, TACOM, ATTN: AMSTA-CZ.

b. Storage areas shall be classified as restricted areas. Radiation levels shall be posted on the warning signs within the restricted areas.

c. Individual testers shall be labeled with Department of Transportation (DOT) Yellow Label II shipping labels, and other required labeling in accordance with AR 385-30.

d. The local fire department shall be notified of radioactive storage locations, and where to contact the LRPO. The installation LRPO shall also be informed of the storage locations.

e. The time that personnel spend in storage areas shall be kept to an absolute minimum.

f. An inventory shall be maintained in accordance with AR 700-64.

g. Providing that the requirements of paragraphs 4-4.1, 4-4.2 and 4-4.3 have been complied with, any number of

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testers can be stored in an approved storage area.

TRANSPORTATION OF TESTERS BY USING UNITS

4-5.1. General. A letter of instruction shall accompany the tester when it is moved from a government controlled facility, and from one job site to another. A sample letter of instruction is located in Appendix G. DD Form 836 (Special Instructions For Motor Vehicle Drivers), may be used as the letter of instruction. The general requirements of AR 385-11 shall be complied with, as shall state and local requirements. It is mandatory that the tester be packed and locked in its approved carrying case during transport. The case shall be properly secured to prevent damage to it and the tester during transport.

4-5.2. Air Drop. The tester is not authorized for air drop.

4-5.3. Air Transportation.

a. The tester is not authorized for shipment on commercial passenger aircraft. Commercial air transportation is governed by DOT regulations.

b. The tester is approved for air transport by helicopter, fixed-wing Army aircraft, Air Force aircraft, and commercial nonpassenger-carrying aircraft when shipped in accordance with TM 38-250, AR 385-11, and applicable DOT and NRC regulations.

SURVEYS AND TESTS

4-6.1. Radiation Surveys. Radiation surveys shall be conducted in accordance with AR 700-64. A copy of the initial survey, while the tester is in the storage area, shall be provided to Commander, TACOM, ATTN: AMSTA-CZ. The survey shall contain, as a minimum, the following information:

a. A sketch of the storage area showing tester location and adjacent offices and buildings.

b. Recorded radiation levels and location of the survey readings.

c. Distance from the tester to the survey location.

d. Location of radiation caution signs.

e. Identification of the instrument used to make the survey, and the date on which the instrument was calibrated.

f. Name of the surveyor.

g. Date of the survey.

h. A statement attesting to the fact the documents specified in paragraph 4-4.3a have been posted.

i. Any corrective actions required and accomplished.

4-6.2. Minimum Requirements for Scheduled Surveys.

a. Check the security of radiation sources and testers.

b. Ensure that the area is posted in accordance with AR 385-30, AR 700-64 and paragraph 4-4.3a, above.

c. Ensure that personnel comply with the radiation safety procedures.

d. Ensure that personnel comply with the SOP for safe handling of the tester and tester security.

e. When a tester storage area is relocated or renovated, perform a new survey in accordance with paragraph 4-6.1. Furnish a copy of the new survey to Commander, TACOM, ATTN: AMSTA-CZ.

4-6.3. Radiation Leak (Wipe) Test.

a. In compliance with AR 385-11, every tester shall be tested for radiation leakage at intervals not to exceed six months. The absence of a certificate of transfer, which would have indicated that a leak test had been made within six months prior to transferring a tester, mandates that the tester shall not be used until it has been tested. The leak test requirement applies to all testers, both in use and in storage. See paragraph 4-6.4 for leak test procedures.

b. Tester users in the US and Puerto Rico shall receive leak test kits every six months. Units not receiving the kits shall notify Commander, TACOM, ATTN: AMSTA-CZ.

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c. Leak test results shall be maintained by the LRPO, and shall be recorded in microcuries.

d. Wipe tests made by users in the US and Puerto Rico shall be sent to: Chief, US Army Ionizing Radiation Dosimetry Center, AMXTM-CE-DCN, Lexington, KY 40511.

e. Wipe tests made by USAREUR units shall be sent to: Nucleonics Branch ACRC, Pirmasens, APO NY 09138.

f. Overseas users in other than USAREUR units will be notified of Army laboratories to which wipe tests shall be sent.

g. Units that receive leak test kits every six months are not required to send test results to TACOM. The test results are forwarded to TACOM by the US Army Ionizing Radiation Dosimetry Center.

h. Users who do not receive leak test kits every six months shall send test results to Commander, TACOM, ATTN: AMSTA-CZ. Test results shall include the LRPO's name, and a statement that the tester is being used only by trained personnel.

(1) The LRPO shall ensure that test results are recorded and submitted on DA Form 3252-R (Punch Card Transmission Worksheet Radioisotope Inventory and Leak Test Report), as required by AR 385-11 and paragraph 4-2.5e.

(2) When filling out the DA Form 3252-R, use the last five digits of the tester serial number for blocks 18-22.

i. The LRPO shall immediately withdraw a tester from use when results of leak testing reveal the presence of 0.005 or more microcuries. Immediately thereafter, the LRPO shall notify the installation's RPO, the RCO, and the Commander, TACOM. The telephone shall be used to notify TACOM. A request for instructions from TACOM shall also be made during the telephone call. TACOM (AMSTA-CZ) telephone numbers are:

(1) During office hours:

Autovon 786-6121/6194
Commercial (313) 574-6121/6194

(2) After office hours:

Autovon 786-5511
Commercial (313) 574-5511

4-6.4. Leak Test Procedure.

4-6.4.1. General.

a. The tester contains two sealed sources. Both of the sources must be tested for radiation leakage to comply with AR 385-11. See paragraph 4-6.3.

b. The following items are required for performing the leak test:

(1) Transparent plastic wrapping material.

(2) Pressure sensitive transparent tape.

(3) Cotton swab.

(4) Detergent and water solution.

(5) Aluminum or other metallic foil.

(6) Radiac meter AN-PDR/27 or equivalent.

4-6.4.2. Leak Test.

a. Place a sheet of clean plastic wrap on an uncontaminated surface near the tester.

b. Make sure the tester's handle is locked in the "SAFE" position, and that the shutter is closed. (See figure 4-1.)

c. Carefully place the tester on its end or side. See figure 4-2.

d. Moisten the cotton swab in the detergent/water solution.

e. Swab the ring which is located on the bottom of the tester. Do not swab the source rod or the shutter. See figure 4-2.

f. Place the cotton swab on the sheet of plastic wrap.

g. Return the tester to its upright position. See figure 4-1.

h. Loosen the four screws which are located in the corners of the tester's display panel. Lift the panel out of the tester and support it on the case. See figure 4-3.

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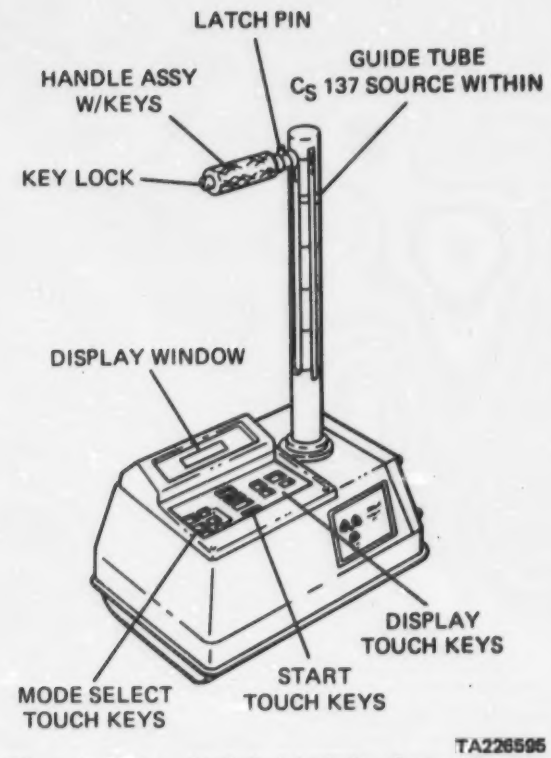

Figure 4-1. Model MC-1 Nuclear Method Density and Soil Tester

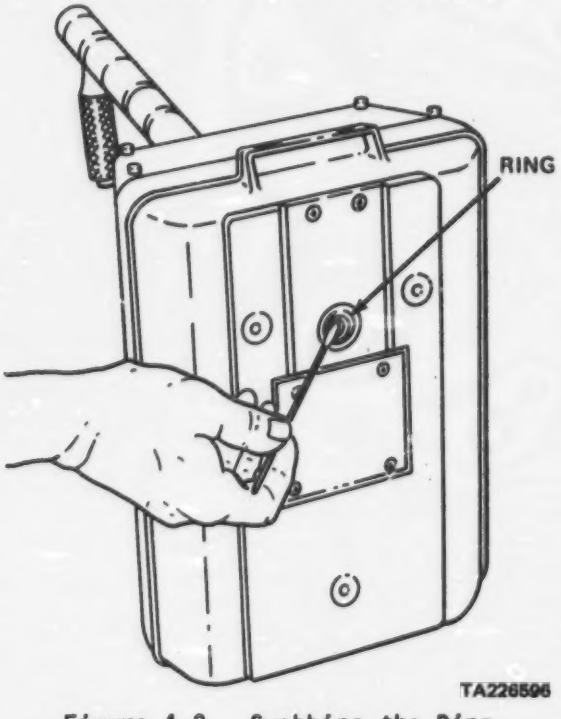

Figure 4-2. Swabbing the Ring

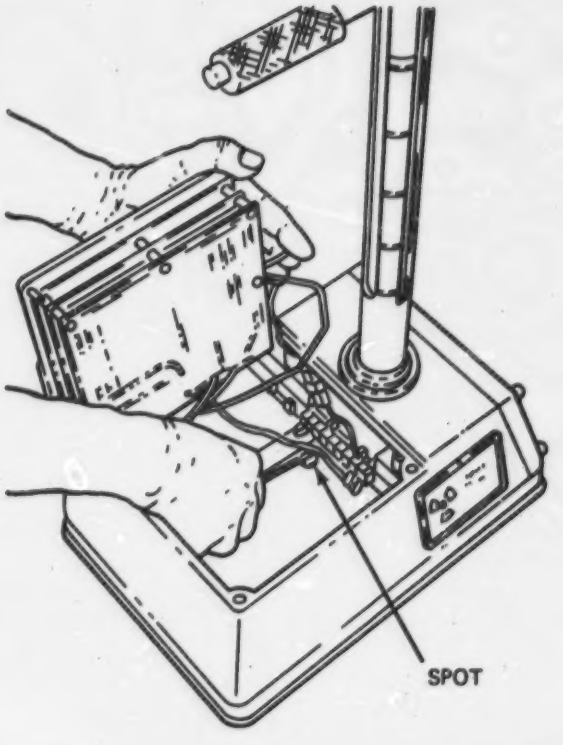

Figure 4-3. Swabbing the Spot

i. With the same swab that was used in e above, swab the red spot which is located within the tester and next to the internal radiation level. The spot to be swabbed may not be painted red in some testers. See figure 4-3.

j. Wrap just the cotton swab and an inch or two of the stick with plastic wrap. Seal the plastic wrap around the stick with cellophane tape.

k. Reinstall the display panel in the tester and tighten the four screws.

l. The swab shall be tested for radiation in an area where background radiation averages 0.04 mrem/hr or less.

(1) Adjust the radiac meter AN-PDR/27 or equivalent to measure 0 to 0.5 mrem/hr.

(2) Open the cover end of the radiac meter's probe.

(3) Do not touch the swab to the meter's probe. Place the swab about 0.25 inch in front of the probe and note the meter reading.

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WARNING

A tester is contaminated when a reading of 0.1 mrem/hr or more is obtained from the swab. Follow the procedures provided in paragraph 4-7.3. The swab is also contaminated.

The tester shall immediately be withdrawn from use when the wipe test indicates a reading of 0.1 mrem/hr, or when the analysis laboratory test results reveal the presence of 0.005 or more microcuries.

m. Cut off the applicator stick at the tape seal.

n. If a swab reading greater than 0.4 mrem/hr was obtained, wrap the sealed swab in several layers of aluminum, lead or other metallic foil, and place it in a small cardboard box. Make sure the box is closed.

o. Monitor the cardboard box for surface radiation. The reading must be below 0.4 mrem/hr before the swab can be mailed to the analysis laboratory. Add additional wrappings of foil to reduce surface radiation below 0.4 mrem/hr.

(1) In the US and Puerto Rico, mail swabs to:

Chief
US Army Ionizing Radiation Dosimetry Center
ATTN: AMXTM-CE-DCN
Lexington, KY 40511

(2) USAREUR units will forward swabs to: Nucleonic Branch ACRC-Pirmasens APO NY 09138

(3) Other tester users shall forward swabs to laboratories indicated in procedures established by the area commander.

4-6.4.3. Records.

a. Record the date of laboratory test results in a permanent file.

b. Units in the US and Puerto Rico that do not receive wipe test kits from the wipe test kit service shall mail laboratory test results to:

Commander
US Army Tank-Automotive
ATTN: AMSTA-CZ (Safety Office)
Warren, MI 48090

EMERGENCY PROCEDURES

4-7.1. Leaks, Loss or Tester Damage (Fire and Explosion).

a. To become qualified, all tester users must have had previous training in procedures for handling emergencies that could occur during transportation of the tester.

b. Personnel responsible for storage facilities must have had previous training in procedures to be followed during emergencies that could occur when the tester is in storage.

(1) Panic must be averted during emergencies.

(2) The first person to discover a radiological incident on a military installation must immediately notify the installation's RPO and Commander, TACOM, ATTN: AMSTA-CZ.

c. When a tester is exposed to or damaged by fire or explosion, personnel who have been trained in emergency procedures shall perform the following duties, in the order given.

(1) Notify all personnel who are not directly involved in the emergency to clear the area.

(2) Notify fire fighting and other emergency personnel of the situation.

(3) When a radiological hazard is not immediately imminent, attempt to extinguish fires with first-aid type extinguishers. Try to prevent water or fire-fighting chemicals from coming into contact with radioactive sources.

(4) Notify the LRPO of the situation.

d. After the emergency, the LRPO shall:

(1) Monitor all personnel who were in the emergency area.

(2) Monitor all personnel who were involved in combating the emergency.

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(3) Monitor the area and determine those protective measures that are necessary for the removal of radiation hazards.

4-7.2. Physical Loss of Tester.

a. When a tester is lost, the LRPO shall attempt to recover the tester by:

(1) Making a physical search for the tester.

(2) Reviewing records to determine the individual who was responsible for the tester.

(3) When the tester cannot be recovered, the LRPO shall report the loss to the radiation material control point (RMCP) and the Commander, TACOM, ATTN: AMSTA-CZ. The report shall include:

(a) Serial number of the lost tester.

(b) Circumstances concerning the loss.

(c) Action taken to prevent recurrence of tester loss.

(4) When the tester is recovered, revise procedures to prevent recurrence of tester loss.

4-7.3. Damaged or Leaking Tester.

a. When a tester is leaking radiation, or is suspected of leaking, the LRPO shall:

(1) Immediately discontinue use of the tester.

(2) Wrap the tester in plastic film and seal the package with tape.

(3) Conspicuously label the package as being contaminated with radioactivity.

(4) Monitor personnel, equipment, and the area for contamination. Decontaminate as required.

(5) Report that the tester is damaged, or leaking, to both the RMCP and the Commander, TACOM, ATTN: AMSTA-CZ.

(6) Dispose of the tester as directed by the NICP, and comply with AR 385-11.

(7) Report the completed disposal action to both the RMCP and the NICP.

b. Shutter Failure. When the tester's source shutter fails to close or is damaged, the LRPO shall:

(1) Immediately discontinue use of tester. Do not attempt to repair the tester.

(2) Place tester in shipping case and lock the case.

(3) Place shipping case in an isolated, locked area and secure it against unauthorized handling.

(4) Report immediately, by telephone, to both the RMCP and Commander, TACOM, AMSTA-CZ, for further instructions.

4-7.4. Personnel Exposed to Radiation.

a. Overexposure.

(1) The individual(s) shall immediately report to the medical officer in the event of suspected or actual overexposure.

(2) The individual(s) shall notify the LRPO of the suspected or actual overdose.

b. Skin.

(1) An individual's skin is considered overexposed when it monitors at a higher instrument reading than that of the previously determined background level.

(2) The individual shall immediately wash, paying particular attention to cleaning fingernails, the hair, and creases in the skin.

c. Cuts and Skin Abrasion. Thoroughly flush the wound with water when contamination is either suspected or confirmed.

d. Ingestion.

(1) Do not smoke, eat or drink when handling the tester or any other radioactive item.

(2) Immediately inform the medical officer when ingestion of radioactive contamination is suspected.

e. Clothing.

(1) Immediately remove clothing that monitors at 0.2 mrem/hr or more at a distance of 2.5 centimeters (about one inch).

(2) Place clothing in a container. Seal and label the container as

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radioactive waste. A garbage can with attached lid, and a plastic bag that has been sealed shut with tape are both considered to be sealed containers.

f. Rags. Place all clean-up rags in sealable containers.

g. Disposing of radioactive waste. Comply with AR 385-11 when disposing radioactive waste.

4-7.5. Personnel Exposed to Excessive Radiation. The following actions shall be taken should an individual receive a dose of ionizing radiation from the tester which exceeds 1.25 rem per calendar quarter, or an accumulated dose in excess of 5 rem per calendar year. Refer to paragraph 5-30, AR 40-5, for procedures for personnel exposed to excessive radiation.

a. The individual shall immediately seek advice from the medical officer, and then notify the unit commander of the overexposure.

b. The unit commander shall remove the individual from duties involving occupation exposure to radiation until subsequent exposure limitations are established by proper medical authority (AR 40-14).

c. The unit commander, with assistance from the LRPO, shall prepare and submit a written report of circumstances leading to the overexposure. The report shall include the following.

(1) Serial number of the tester that caused the overexposure.

(2) Action taken to prevent recurrence of overexposure.

d. Overexposure reports shall be forwarded, through command channels, to the Commander, TACOM, ATTN: AMSTA-CZ.

4-7.6. Decontamination of Equipment and Area.

a. Make sure not to spread the contaminant during the decontaminating process.

(1) Ensure that contamination has not spread by monitoring the area of contamination with survey instrumentation while wearing protective clothing and shoe covers.

(2) During the decontaminating process, always work from the areas of least contamination toward the areas of greatest contamination.

(3) Use the minimum amount of decontaminating solutions. Remain alert to the fact that run-off solutions, mops, rags and brushes are contaminated.

b. Accomplish decontaminating methods in the following order of priority:

(1) Damp mopping. Wipe the contaminated area with a damp rag or a damp mop. Keep changing the wiping surface of the rag or mop to minimize spreading the contaminant.

(2) Water and detergent. Wet the contaminated area with a rag or mop which has been dampened with a minimum amount of detergent solution. Then, wipe the area dry with absorbent gauze or cloth.

WARNING

Before proceeding to the next decontamination level, contact the Commander, TACOM, ATTN: AMSTA-CZ for guidance concerning respiratory protection. Failure to wear respiratory protection may result in overexposure to radiation.

(3) Steam cleaning.

(4) Cleaning with solvents other than water.

(5) Surface removal by use of chemicals, abrasives, sand blasting and grinding.

c. The only vacuum cleaners that shall be used are those with absolute filters which have been tested for filtration efficiency. Testing filtration efficiency is mandatory each time the filter is replaced, and each time its contents are emptied.

d. Radioactive waste shall be disposed of in a manner to comply with AR 385-11.

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MAINTENANCE

4-8.1. Tester Maintenance.

a. Only limited and specific maintenance is authorized for the tester. Personnel authorized to perform maintenance are the operator and the LRPO. Neither the operator nor the LRPO are authorized to repair the tester (see para 4-8.2).

b. Operator performed maintenance is limited to the following:

(1) Cleaning the tester's external surfaces and shutter assembly.
(2) Changing fuses.
(3) Changing batteries.
(4) Charging batteries.
(5) Testing batteries.

c. LRPO performed maintenance is limited to the following:

(1) Perform the leak test.
(2) When required, the LRPO shall perform maintenance that is normally accomplished by the operator.

4-8.2. Tester Repair and Disposal.

a. A tester requiring repair or disposal must be returned to a designated manufacturer's repair facility.

b. Do not use the tester when it fails to operate in accordance with pre-operation checks described in the operator's manual.

c. Contact the NICP for disposition instructions. See paragraph 4-9.2a.

d. Contact the Commander, TACOM, ATTN: AMSTA-MVB if all operating modes of the tester are not functioning correctly. Users are requested to submit a Quality Deficiency Report (QDR) on Standard Form 368 in accordance with DA Pam 738-750 to the address in paragraph 4-9.2b.

ASSISTANCE

4-9.1. Safety. Copies of surveys, leak test results, incident reports, other applicable data and reports, DA Form 3252-R, and questions pertaining to the tester and personnel safety shall be directed to:

Commander
US Army Tank-Automotive Command
ATTN: AMSTA-CZ (Safety Office)
Warren, MI 48090
Telephone:
Autovon: 786-6121 or 6194
Commercial: (313) 574-6121 or 6194
After office hours:
Autovon: 786-5511
Commercial: (313) 574-5511

4-9.2. Tester Requisition, and Disposition. Questions or requests pertaining to tester requisition, and disposition shall be directed to:

a. Commander
US Army Tank-Automotive Command
ATTN: AMSTA-FHM (NICP)
Warren, MI 48090
Telephone:
Autovon: 786-5345
Commercial: (313) 574-5345

Questions pertaining to tester maintenance shall be directed to:

b. Commander
US Army Tank-Automotive Command
ATTN: AMSTA-MVB (Maintenance)
Warren, MI 48090
Telephone:
Autovon: 786-7349/7358

4-9.3. Training Courses. Questions pertaining to training courses shall be directed to:

a. Tester training course.
Commander
US Army Tank-Automotive Command
ATTN: AMSTA-MLM (Technical Assistance)
Warren, MI 48090
Telephone:
Autovon: 786-5818
Commercial: (313) 574-5818

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b. Material Quality Specialist course - including tester training.
Commandant
US Army Engineer School
ATTN: ATZA-TE-RA
Fort Belvoir, VA 22060
Telephone:
Autovon: 354-2889
Commercial: (703) 664-2889

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SECTION V

SUPPLEMENTAL OPERATING, MAINTENANCE AND REPAIR PARTS INSTRUCTIONS (SOMARPI) FOR TESTER, DENSITY AND MOISTURE (SOIL AND ASPHALT) NUCLEAR METHOD

CAMPBELL PACIFIC NUCLEAR CORPORATION MODEL MC-1 (NSN 6635-01-030-6896)

5-1. Instructions.

a. These instructions contain supplemental information for Army users and are Army oriented instructions to assist in managing and expediting maintenance repair parts supply, technical assistance, and user problems.

b. Weapons System Designator Code for requisitioning is 3M.

5-2. General.

a. The Density and Moisture Tester is a Commercial Construction Equipment (CCE) type used to measure the density and moisture content of soils, soil-stone aggregates, and also the density of hot asphalt while the mix is being compacted.

b. Operation of the tester will be only by personnel who have successfully completed an Operators Training Course as defined in section IV. Operation will be supervised by a Local Radiation Protection Officer (LRPO) who has successfully completed the training requirements as stated in paragraph 4-2.5c. Radiation Control Officers of Major Commands will monitor the LRPO's. The TACOM Safety Office will insure compliance with the Nuclear Regulatory Commission (NRC) license by monitoring reports of inventory, leak tests, incidents and equipment improvement, by utilizing feedback from Logistics Assistance and Inspection Teams, and by liaison with Radioactive Material Control Points (For details, see Section IV).

5-3. Maintenance Concept.

a. Organizational maintenance consisting of external cleaning, battery charging and replacement, fuse changing, shutter cleaning/lubricating, will be performed by the operator. Wipe (leak) tests will be performed by the LRPO.

b. TACOM, as required, will issue a Task Order/Work Directive/Order for all supplies and services for major repairs to the contractor authorizing necessary work. TACOM can place a dollar limit on work authorized. TACOM will furnish users shipping instructions of designated repair facility. (Users will retain and use the original container, for shipping testers for repair).

c. Contractor will repair or overhaul testers and ship them back to users.

d. The contractor will bill the government for his labor, materials, parts and shipping cost.

e. TACOM will obtain confirmation from the using unit that repairs have been accomplished and will authorize payment of the repair bill.

f. The contractor will be responsible for disposing of unserviceable, unrepairable testers upon receipt of disposal instructions from NICP at TACOM.

5-4. Support Organizations.

a. Maintenance - None. All maintenance above organization (see paragraph 5-3.a.) will be obtained by evacuation to the designated contractor's facility.

b. Supply - DS units backing up the using units will process requests for parts shown on the PLL and ASL. See Appendix D.

5-5. Repair Parts and Support.

Requisitions will be forwarded to and filled by DCSC. Routing identified code (SC9) under milstrip procedures (AR 725-50) for non-NSN items see appendix H, for NSN items see appendix I,

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Requisitions should cite manufacturer's part numbers in the absence of NSN's.

5-6. Personnel and Training.

a. All operational and support personnel will require training on the safe handling of nuclear devices (see paragraph 4-2.8).

b. MOS Training: TRADOC will manage and coordinate the MOS training of operators. This training will be conducted by the US Army Engineer School at Fort Belvoir, Virginia.

5-7. Equipment Publications.

a. Initially two sets of the Commercial Instruction Manuals, supplemented by a separate SOMARPI and TB 385-103 (Safety Procedures) were issued to support the soil tester.

b. After initial issue of Tester, the manufacturers Manuals, the SOMARPI and TB 385-105 were combined into this DA Authenticated Manual from TAG. The Manual Number is TM 5-6635-386-12&P.

5-8. Facilities.

a. No special maintenance facilities are required for the tester.

b. For storage facilities see Section IV, paragraph 4-4.1 in this manual.

5-9. Technical Assistance. The US Army Tank-Automotive Command (TACOM) has technical assistance, per AR 700-4, available at the following location:

Commander
US Army Tank-Automotive Command
ATTN: AMSTA-ML
Warren, Michigan 48090

5-10. Equipment Improvement Recommendation (EIR's). EIR's will be submitted in accordance with instructions contained in DA PAM 738-750.

5-11. Destruction to Prevent Enemy Use. When the tester cannot be evacuated the following will be done:

1. Remove the circuit boards and display panel (loosen and remove the four screws located in the corners of the tester's display panel, pull off panel, and cut or disconnect wiring).

2. Destroy the display panel and circuit boards by crushing.

3. Destroy worksheet and logs by crushing, tearing, and burying, or scattering over a sufficiently large area to make recovery improbable.

4. Abandon the remainder of the tester.

5-12. Shipment and Storage. In addition to operating and maintenance instructions, see Section IV, SAFETY PROCEDURES, in this manual.

5-13. Manufacturer's Safety Defects. If any manufacturer's safety defects occur, upon notification TACOM will advise users on action to be taken for correction and reporting.

5-14. Manufacturer's Field Campaigns and Modifications. Modifications are not anticipated. If necessary, they will be applied by CPN after TACOM's approval of the field campaign or modification plan.

5-15. Basic Issue Item List. List of items which accompany the Tester or are required for installation, operation, or operator maintenance (Appendix C).

5-16. Personnel Dosimetry. See Section IV in this manual.

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APPENDIX A

REFERENCES

A-1. SCOPE

This appendix lists all forms, field manuals, technical manuals and miscellaneous publications referenced in this manual.

A-2. FORMS

Radioisotope Inventory and Leak Test Report. . . . . DA Form 3252-R
Photodosimetry Report. . . . . DA Form 3484
Record of Occupational Exposure to Ionizing Radiation. . . . . DD Form 1141
Film Badge Application and Record of Occupational Radiation Exposure . . . . . DD Form 1952
Notice to Employees. . . . . NRC Form 3
Quality Deficiency Report. . . . . SF 368
Special Instructions for Motor Vehicle Drivers . . . . . DD Form 836
Moisture and Density Tester Field Data Worksheet..... DA Form 5448-R

A-3. ARMY REGULATIONS

Health and Environment . . . . . AR 40-5
Control and Recording Procedures for Occupational Exposure to Ionizing Radiation. . . . . AR 40-14
Ionizing Radiation Protection. . . . . AR 385-11
Safety Color Code Markings and Signs . . . . . AR 385-30
Radioactive Commodities in the DOD Supply System . . . . . AR 700-64

A-4. TECHNICAL MANUALS

Preparation of Hazardous Materials for Military Air Shipment . . . . . TM 38-250

A-5. TECHNICAL BULLETINS

Calibration Requirements of the Maintenance of Army Material . . . . . TB 43-180

A-6. DA PAMPHLETS

The Army Maintenance Management System (TAMMS) . . . . . DA PAM 738-750

A-7. MISCELLANEOUS DOCUMENTS

Energy Reorganization Act of 1974, Section 206 . . . . . Public Law 93-438
Code of Federal Regulations, United States Nuclear Regulatory Commission, Rules and Regulations . . . . . Title 10
Code of Federal Regulations, Part 1910, Occupational Safety and Health Standards . . . . . Title 29
US Department of Transportation Regulations

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APPENDIX B

MAINTENANCE ALLOCATION CHART

FOR

TESTER, DENSITY AND MOISTURE (SOIL AND ASPHALT), NUCLEAR METHOD

SECTION I - INTRODUCTION

1. **General.** This Maintenance Allocation Chart designates responsibility for performance of maintenance repair functions at specified maintenance levels.

a. Section I is a general explanation and definition of terms.

b. Section II shows the maintenance level responsible and estimated work measurement time for specific functions.

c. Section III lists common tool sets and the special tool, test and support equipment required for each maintenance function shown in section II.

2. **Explanation of Columns in Section II.**

a. Column 1, Group number. Column 1 lists group numbers, the purpose of which is to identify components, assemblies, subassemblies, and modules with the next higher assembly.

b. Column 2, Component/Assembly. Column 2 contains the noun names of components, assemblies, subassemblies, and modules for which maintenance is authorized.

c. Column 3, Maintenance Functions. Column 3 lists the functions to be performed on the item listed in Column 2.

d. Column 4, Maintenance Category. Column 4 specifies, by the listing of a "work time" figure in the appropriate subcolumn (s), the lowest level of maintenance authorized to perform the function listed in Column 3. This figure represents active time required to perform that maintenance function at the indicated category of maintenance. The number of man-hours specified by the "work time" figure represents the average time required to restore an item to a serviceable condition under typical field operating conditions. This time includes preparation time, troubleshooting time, and quality assurance/quality control time in addition to the time required to perform the specific tasks identified for the maintenance functions authorized in the maintenance allocation chart. The subcolumns are:

C - Operator/Crew
O - Organizational
F - Direct Support
H - General Support
D - Depot

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APPENDIX B - CONTINUED

e. Column 5, Tools and Equipment. Column 5 specifies by code, those common tool sets (not individual tools) and special tools, test, and support equipment required to perform the designated functions.

3. The maintenance functions are defined as follows:

a. Inspect. To determine the serviceability of an item by comparing its physical, mechanical and/or electrical characteristics with established standards through examination.

b. Test. To verify seviceability and detect incipient failure by measuring the mechanical or electrical characteristics of an item and comparing those characteristics with prescribed standards.

c. Service. Operations required periodically to keep an item in proper operating condition, i.e., to clean (decontaminate), to preserve, to drain, to paint, or to replenish fuel, lubricants, hydraulic fluids, or compressed air supplies.

d. Adjust. To maintain, within prescribed limits, by bringing into proper or exact position, or by setting the operating characteristics to specified parameters.

e. Align. To adjust specified variable elements of an item to bring about optimum or desired performance.

f. Calibrate. To determine and cause corrections to be made or to be adjusted on instruments or test measuring and diagnostic equipments used in precision measurement. Consists of comparisons of two instruments, one of which is a certified standard of known accuracy, to detect and adjust any discrepancy in the accuracy of the instrument being compared.

g. Install. The act of emplacing, seating, or fixing into position an item, part, or module (component or assembly) in a manner to allow the proper functioning of an equipment or system.

h. Replace. The act of substituting a serviceable like type part, subassembly, or module (component or assembly) for an unserviceable counterpart.

i. Repair. The application of maintenance services (inspect, test, service, adjust, align, calibrate, or replace) or other maintenance actions (welding, grinding, riveting, straightening, facing, remachining or resurfacing) to restore serviceability to an item by correcting specific damage, fault, malfunction, or failure in a part, subassembly, module (components or assembly), end item, or system.

j. Overhaul. That maintenance effort (service/action) necessary to restore an item to a completely serviceable/operational condition as prescribed by maintenance standards (i.e., DMWR) in appropriate technical publications. Overhaul is normally the highest degree of maintenance performed by the Army. Overhaul does not normally return an item to like new condition.

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APPENDIX B - CONTINUED

k. Rebuild. Consists of those services/actions necessary for the restoration of unserviceable equipment to a like new condition in accordance with original manufacturing standards. Rebuild is the highest degree of materiel maintenance applied to Army equipment. The rebuild operation includes the act of returning to zero those age measurements (hours/miles, etc.) considered to classifying Army equipments/components.

MAINTENANCE ALLOCATION CHART FOR TESTER, DENSITY & MOISTURE (SOIL & ASPHALT) NUCLEAR METHOD (CCE)

SECTION II - ASSIGNMENT OF MAINTENANCE FUNCTIONS

(1) Group Number	(2) Component/Assembly	(3) Maintenance Function	(4) Maintenance Category C	O	F	H	D	(5) Tools and Equipment
	Battery	Inspect	0.1					
		Test	0.1					
		Service	0.1					
		Replace	0.1					
	Shutter/Cleanout Plate	Service	0.1					
		Replace					*	
	Fuses	Test	0.1					
		Replace	0.1					
	End Item	Inspect	0.1					
		Test		0.2**				
		Service	0.1					
		Adjust	0.1					
		Calibrate					*	
		Replace					*	
		Repair					*	
		Overhaul					*	

* By Manufacturer
** This operation performed by the LRPO

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APPENDIX B - CONTINUED

SECTION III - TOOL AND TEST EQUIPMENT REQUIREMENTS

Tool or Test Equipment Reference Code	Maintenance Category	Nomenclature	National/NATO Stock Number	Tool Number

NOTE

Wipe test kits will be supplied by the US Army Ionizing Radiation Dosimetry Center.

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APPENDIX C

COMPONENTS OF END ITEM AND BASIC ISSUE ITEMS LISTS

SECTION I. INTRODUCTION

C-1. SCOPE

This appendix lists components of end item and basic issue items for the Density and Moisture Tester to help you inventory items required for safe and efficient operation.

C-2. GENERAL

The Components of End Item and Basic Issue Items Lists are divided into the following sections:

a. Section II. Components of End Item. This listing is for informational purposes only, and is not authority to requisition replacements. These items are part of the end item, but are removed and separately packaged for transportation or shipment. As part of the end item, these items must be with the end item whenever it is issued or transferred between property accounts. Illustrations are furnished to assist you in identifying the items.

b. Section III. Basic Issue Items. These are the minimum essential items required to place the Density and Moisture Tester in operation, to operate it, and to perform emergency repairs. Although shipped separately packaged, BII must be with the Density and Moisture Tester during operation and whenever it is transferred between property accounts. The illustrations will assist you with hard-to-identify items. This manual is your authority to request/requisition replacement BII, based on TOE/MTOE authorization of the end item.

C-3. EXPLANATION OF COLUMNS

The following provides an explanation of columns found in the tabular listings:

a. Column (1) - Illustration Number (Illus Number). This column indicates the number of the illustration in which the item is shown.

b. Column (2) - National Stock Number. Indicates the National stock number assigned to the item and will be used for requisitioning purposes.

c. Column (3) - Description. Indicates the Federal item name and, if required, a minimum description to identify and locate the item. The last line for each item indicates the FSCM (in parentheses) followed by the part number.

d. Column (4) - Unit of Measure (U/M). Indicates the measure used in performing the actual operational/maintenance function. This measure is expressed by a two-character alphabetical abbreviation (e.g., ea, in, pr).

e. Column (5) - Quantity required (Qty rqr). Indicates the quantity of the item authorized to be used with/on the equipment.

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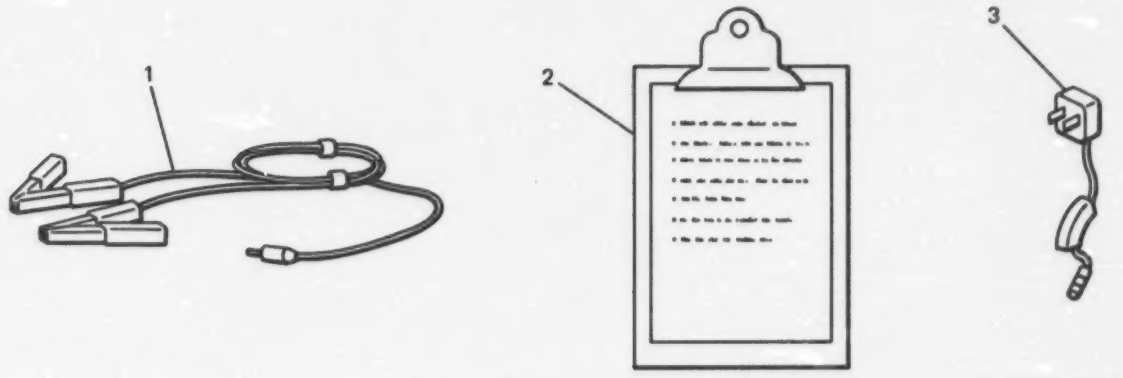
SECTION II. COMPONENTS OF END ITEM

(NOT APPLICABLE)

SECTION III. BASIC ISSUE ITEMS



TA 230982

(1) ILLUSTRATION NUMBER	(2) NATIONAL STOCK NUMBER	(3) DESCRIPTION FSCM and PART NUMBER	(4) U/M	(5) QTY RQR
1	6635-01-043-7973	Cable, DC charger, battery clips (55492) A 401234	ea.	1
		Case assembly, MC (55492) A 401228	ea.	1
2	7520-01-115-8066	Clipboard assembly, MC-1 (55492) B 101013	ea.	1
3		Charger, 8 D NICAD'S (55492) A 400597	ea.	1

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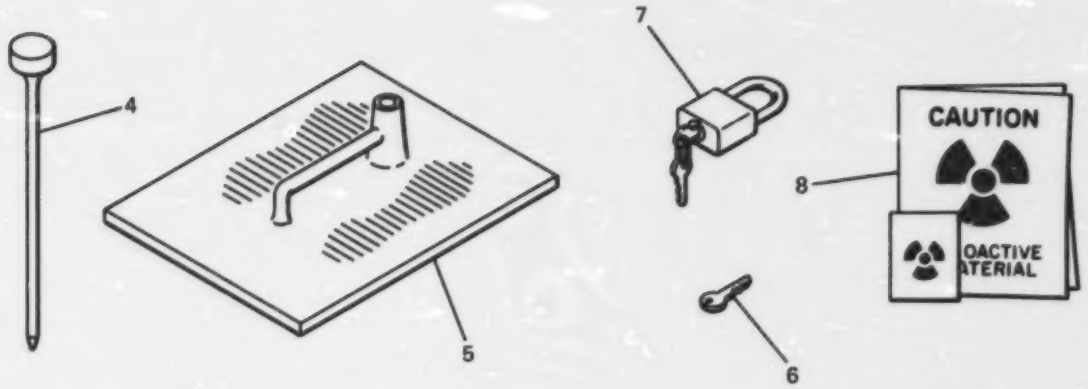
SECTION III. BASIC ISSUE ITEMS - CONTINUED



TA 230983

(1) ILLUSTRATION NUMBER	(2) NATIONAL STOCK NUMBER	(3) DESCRIPTION FSCM and PART NUMBER	(4) U/M	(5) QTY RQR
4		Drill pin, forged (55492) B 100035	ea.	1
5	6635-01-043-7970	Guide plate, cast aluminum (55492) B 200050	ea.	1
6		Key, for A 401128 handle assembly (55492) BPW-1	ea.	1
7		Padlock w/2 keys (55492) AC 20E254	ea.	1
	5120-00-724-3766	Screwdriver, Phillips #4 (55492) PH1-3	ea.	1
8		Sign, kit, caution (55492) B 101085	ea.	1

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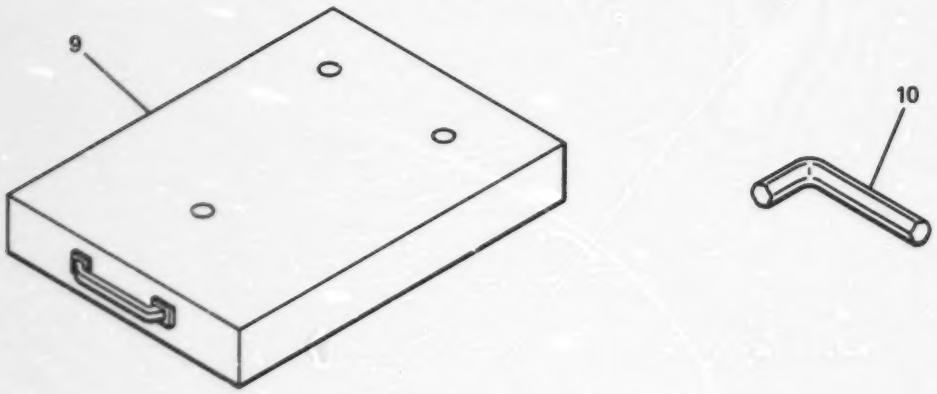
SECTION III. BASIC ISSUE ITEMS - CONTINUED



TA 230984

(1) ILLUSTRATION NUMBER	(2) NATIONAL STOCK NUMBER	(3) DESCRIPTION FSCM and PART NUMBER	(4) U/M	(5) QTY RQR
9		Standard block assembly, MC (55492) B 401124	ea.	1
10	5120-00-198-5392	Wrench, Allen hex, 5/32 (55492) H-1064	ea.	1

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APPENDIX D

PRESCRIBED LOAD LIST (PLL)
AUTHORIZED STOCKAGE LIST (ASL)

END ITEM	MAKE	MODEL
Tester, Nuclear Soil Density/Moisture	CPN CORP SIMUL-TEST	M82AB114 MC-1 SIMUL-TEST

MFR PART NO	NSN	SERIAL NUMBER RANGE	DATE
M82AB114	6635-01-030-6896	_____TO_____	

SMR CODE	NATIONAL STOCK NUMBER	PART NUMBER	FSCM	PART DESCRIPTION	U/M	Qty of Parts For No. of End Item		
						PLL	ASL	
						1-5	1-5	6-20
		MDL - 1-1/2	55492	Fuse, 1.5 Amp Slo-blo AG (Box of 5)	BX	1	5	10
	6140-00-497-0490	403064-000	55492	Battery, NICAD Size D, 4 Amperehour 160°F Special Characteristic	Ea	4-8	10	20

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APPENDIX E

EXPENDABLE/DURABLE SUPPLIES and MATERIALS LIST

SECTION I. INTRODUCTION

D-1. SCOPE

This appendix lists expendable supplies and materials you will need to operate and maintain the tester. This listing is for informational purposes only and is not authority to requisition the listed items. These items are authorized to you by CTA 50-970, Expendable/Durable Items (except Medical, Class V, Repair Parts, and Heraldic Items).

D-2. EXPLANATION OF COLUMNS

a. Column (1) - Item number. This number is assigned to the entry in the listing and is referenced in the narrative instructions to identify the material (e.g., "Use cleaning compound, item 5, App. D").

b. Column (2) - Level. This column identifies the lowest level of maintenance that requires the listed item.

C - Operator/Crew

c. Column (3) - National Stock Number. This is the National stock number assigned to the item; use it to request or requisition the item.

d. Column (4) - Description. Indicates the Federal item name, and, if required, a description to identify the item. The last line for each item indicates the FSCM (in parenthesis) followed by the part number.

e. Column (5) - Unit of Measure (U/M). Indicates the measure used in performing the actual maintenance function. This measure is expressed by a two-character alphabetical abbreviation (e.g., ea, pr, in). If the unit of measure differs from the unit of issue, requisition the lowest unit of issue that will satisfy your requirements.

SECTION II. EXPENDABLE/DURABLE SUPPLIES and MATERIALS LIST

(1) ITEM NUMBER	(2) LEVEL	(3) NATIONAL STOCK NUMBER	(4) DESCRIPTION	(5) U/M
1	C	6850-00-664-5685	Solvent, drycleaning, type II (81348) PD-680	qt
2	C	9150-00-163-9036	Lubricant, molybdenum - disulphide, spray (25873) D 5330	
3	C	9150-00-111-4252	Lubricant, spray (53450) 229-49 A	

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APPENDIX F

MC-1 MAJOR SUB-ASSEMBLIES PARTS

REFERENCE DWG C-401216-A

ITEM NO.	PART NO.	DESCRIPTION
1	403064-000	Battery - cell, NICAD, D, 4 ah
2	B 401247	Battery holder - assembly (less battery - cells)
3	A 401411	Cable, DC charger, cigarette lighter
4	A 400180	Cover battery access, MC
5	MDL-1-1/2	Fuse 1-1/2 SB
6	B 401128	Handle - assembly w/keys
NI	T 401280	PC - assembly, battery clip

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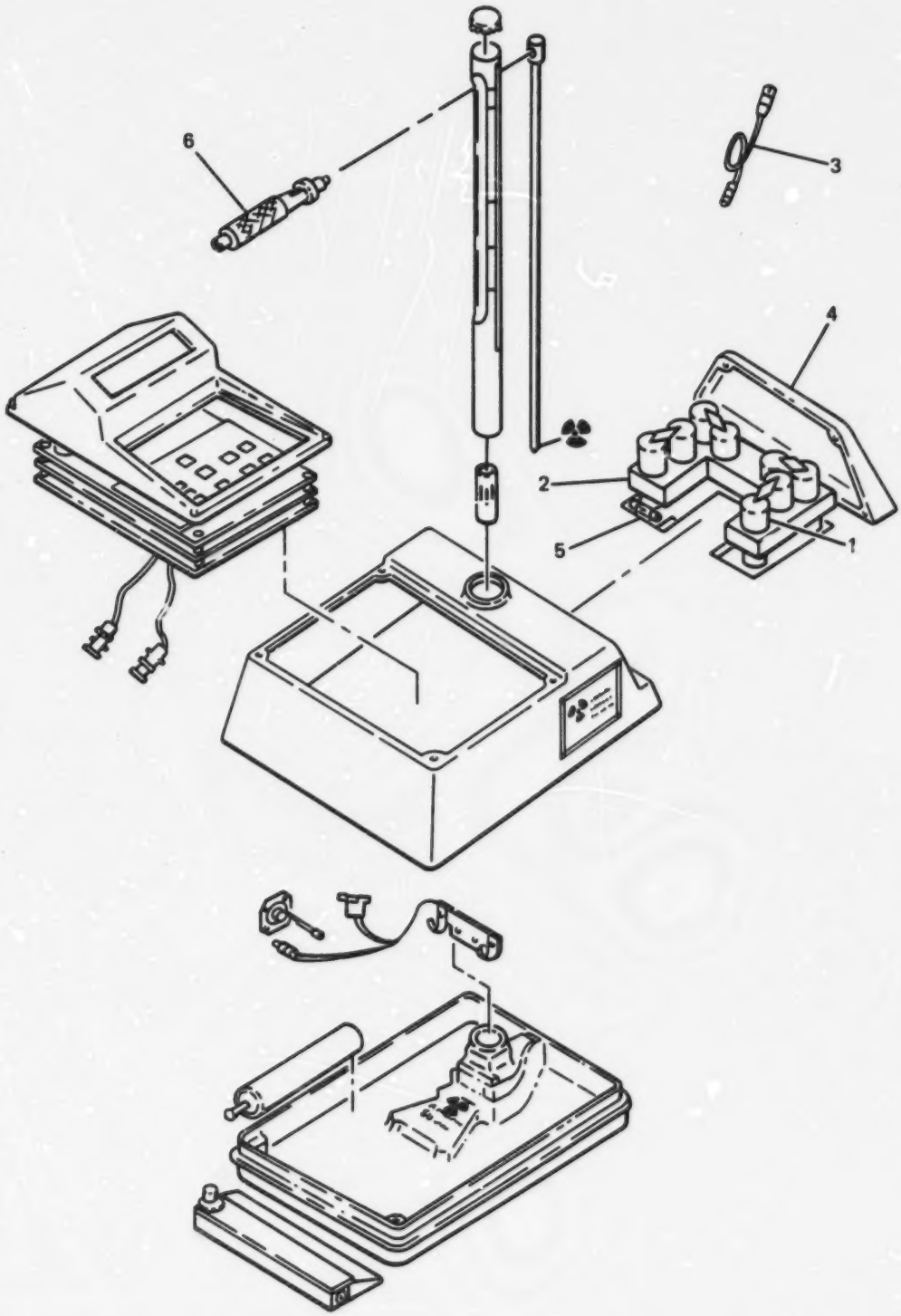

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APPENDIX G

LETTER OF INSTRUCTION

This letter is to be carried by the vehicle driver!

Item being Transported: Tester, Density and Moisture, Nuclear Method, NSN 6635-01-030-6896

Radioactive Sources: 50 millicuries Americium 241 and 10 millicuries Cesium-137 sealed in double encapsulated stainless steel.

Unit Issued the Tester (including mailing address):

Commander's Name and Telephone Number:

Local Radiation Protection Officer's (LRPO) Name and Telephone Number:

Tester being transported to:

Tester being transported from:

Date(s) of Travel:

NOTE

Tester must be transported in its original carrying case and the case shall be locked. If the tester becomes damaged as a result of a vehicle accident notify the LRPO immediately. Refer to Section IV, EMERGENCY PROCEDURES for emergency instructions.

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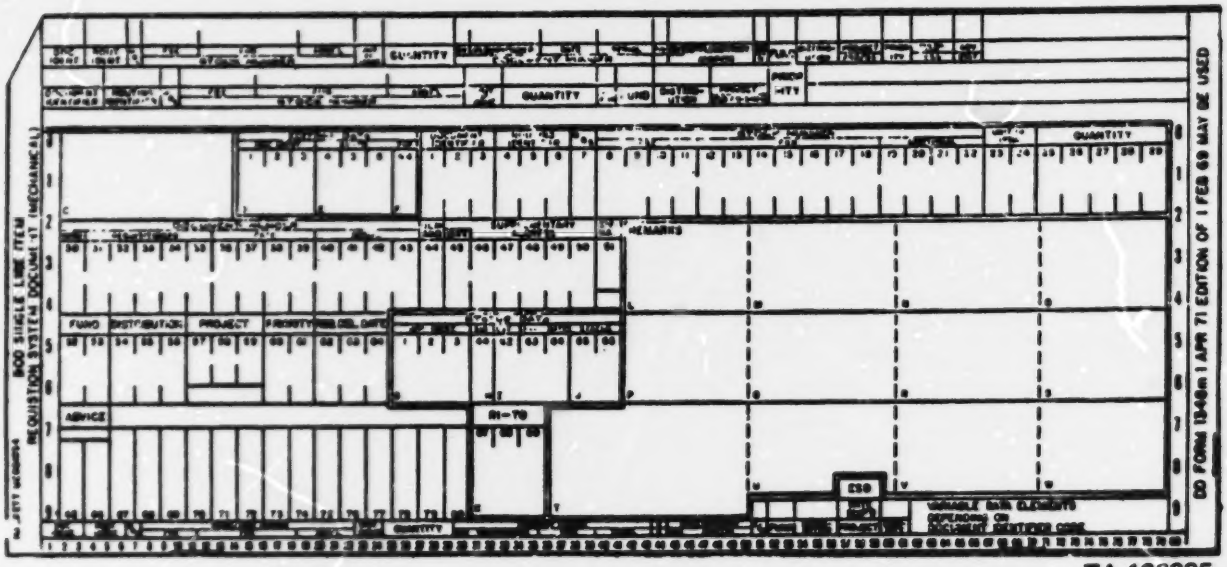
APPENDIX H

SAMPLE FORMAT - MILSTRIP REQUISITION FOR CCE (NON-NSN)



TA 126335

CARD COLUMN	DESCRIPTION OF DATA	MANDATORY ENTRY FOR CCE
1-3	Document Identifier Code	AØB - CONUS AØ2 - Overseas
4-6	Routing Identifier Code	Always S9C
7	Media/Status Code	
8-22	FSCM and Part Number	
23-24	Unit of Issue	
25-29	Quantity	
30-43	Document Number	
44	Demand Code	
45-50	Supplementary Address	
51	Signal Code	
52-53	Fund Code	
54-56	Distribution Code CC-54	"F" for CONUS; see AR 725-50 for OCONUS
	CC-55-56	Weapon System Code
57-59	Project Code	"BWG" for CONUS;"JZC" for OCONUS
60-61	Priority Code	
62-64	Required Delivery Date	
65-66	Advice Code	

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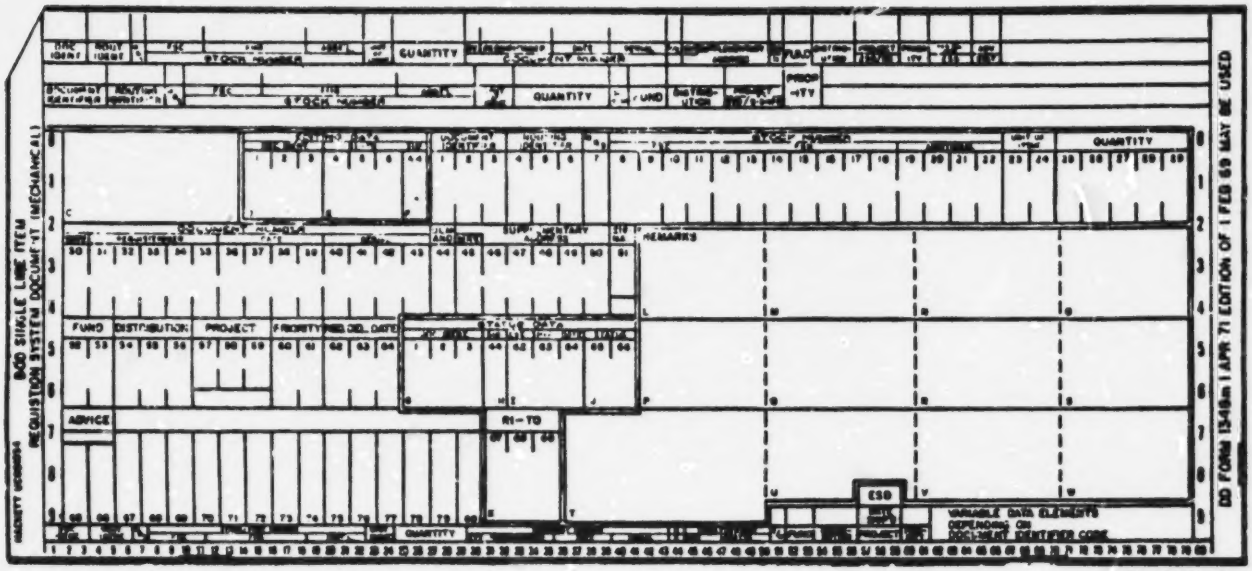
APPENDIX I

SAMPLE FORMAT - MILSTRIP REQUISITION FOR CCE (NSN)



TA 126334

CARD COLUMN	DESCRIPTION OF DATA	MANDATORY ENTRY FOR CCE
1-3	Document Identifier Code	AØA - CONUS AØ1 - Overseas
4-6	Routing Identifier Code	
7	Media/Status Code	
8-22	NSN	
23-24	Unit of Issue	
25-29	Quantity	
30-43	Document Number	
44	Demand Code	
45-50	Supplementary Address	
51	Signal Code	
52-53	Fund Code	
54-56	Distribution Code CC-54	"F" for CONUS; see AR 725-50 for OCONUS
	CC-55-56	Weapon System Code
57-59	Project Code	"BWG" for CONUS; "JZC" for OCONUS
60-61	Priority Code	
62-64	Required Delivery Date	
65-66	Advice Code	

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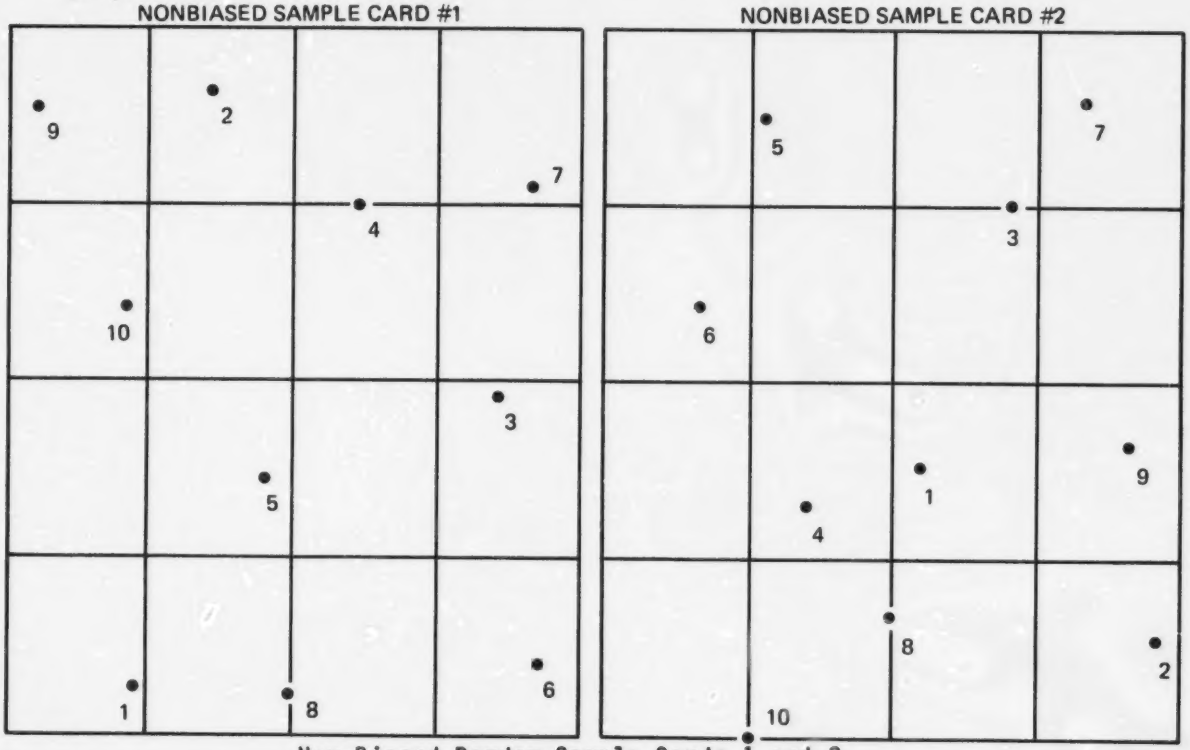
APPENDIX J

AREA CONCEPT TESTING

AREA CONCEPT TESTING provides for the evaluation of a site by use of several readings on the site to give a larger representative sample than a single test would give. The average of the several readings is used to approve or disapprove the site quality. It is desireable to select the reading locations at random to maintain the objectivity of the statistical approach.

The following RANDOM SAMPLE CARDS provide this objectivity in selection. They were produced by a random computer plot, different for each card.

1. Select a card from a shuffled deck. Visualize the card as a map of the project to be tested.
2. Use the <u>average</u> of five readings to pass or fail. Select <u>High</u>, <u>Low</u>, <u>Even</u>, or <u>Odd</u>. This will select which five combinations out of the ten spots on the card are to be used.
3. Identify the exact reading site by location data using the card as the guide. Then go to the five locations and take a nuclear tester reading at each site, using backscatter or transmission as req'd.
4. Average the five readings and pass or fail the site.
5. Should differences in soil characteristics be suspected, take a shovelful of soil from each site and prepare a composite Proctor for optimum value preparation.



Non-Biased Random Sample Cards 1 and 2

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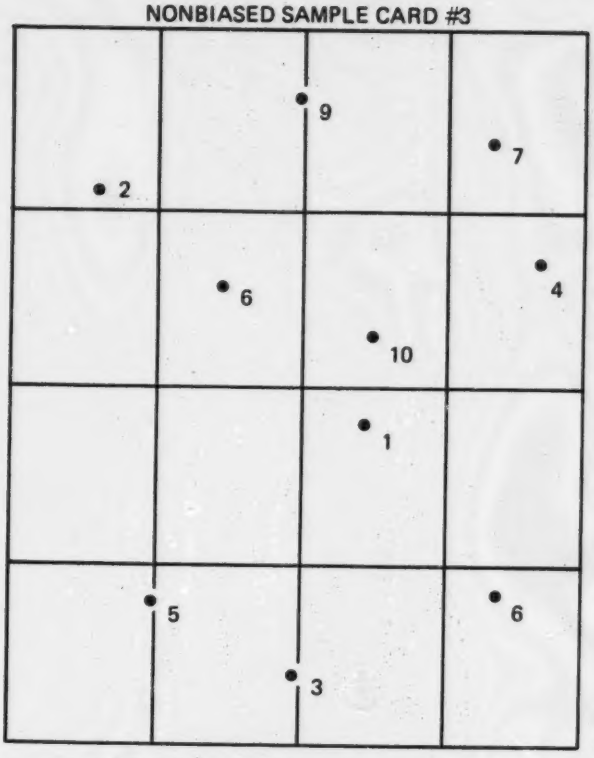
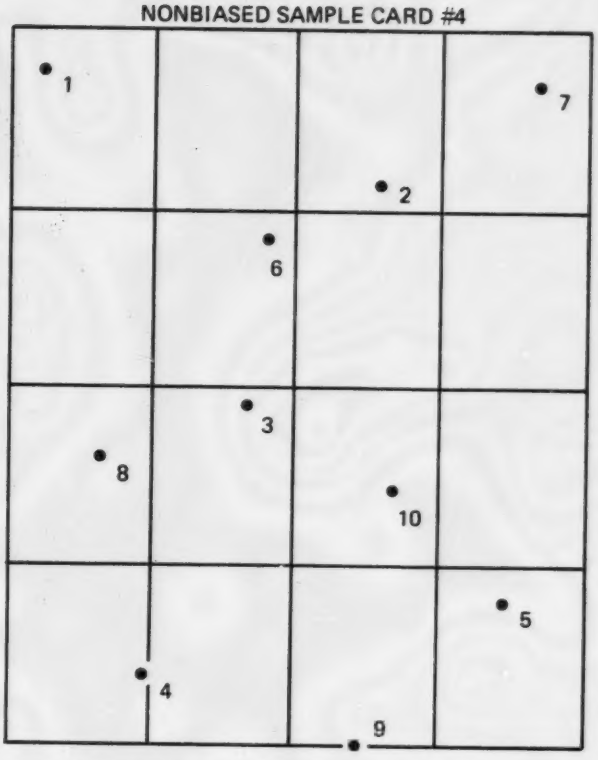
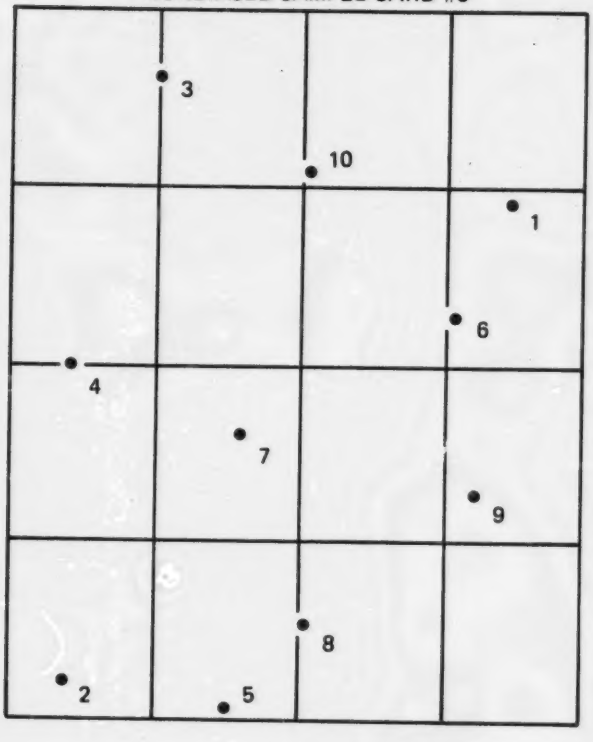
NONBIASED SAMPLE CARD #3



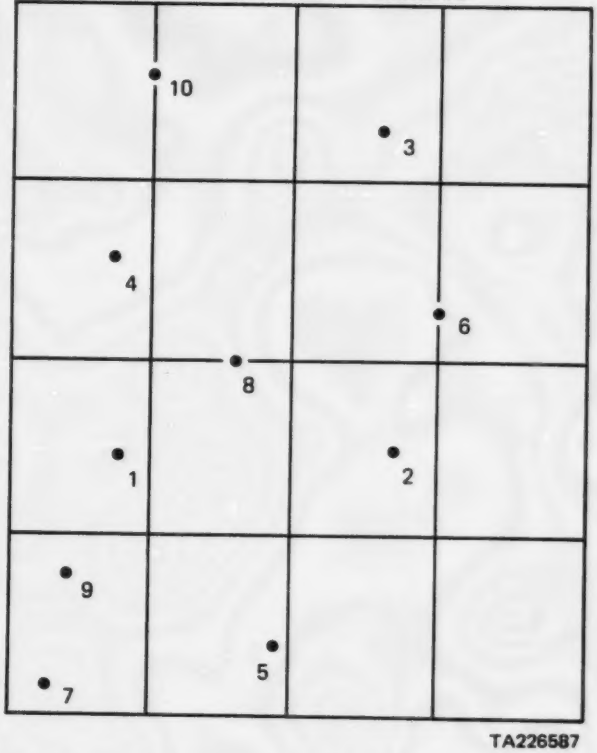
NONBIASED SAMPLE CARD #4



NONBIASED SAMPLE CARD #5



NONBIASED SAMPLE CARD #6



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Non-Biased Random Sample Cards 3, 4, 5, and 6

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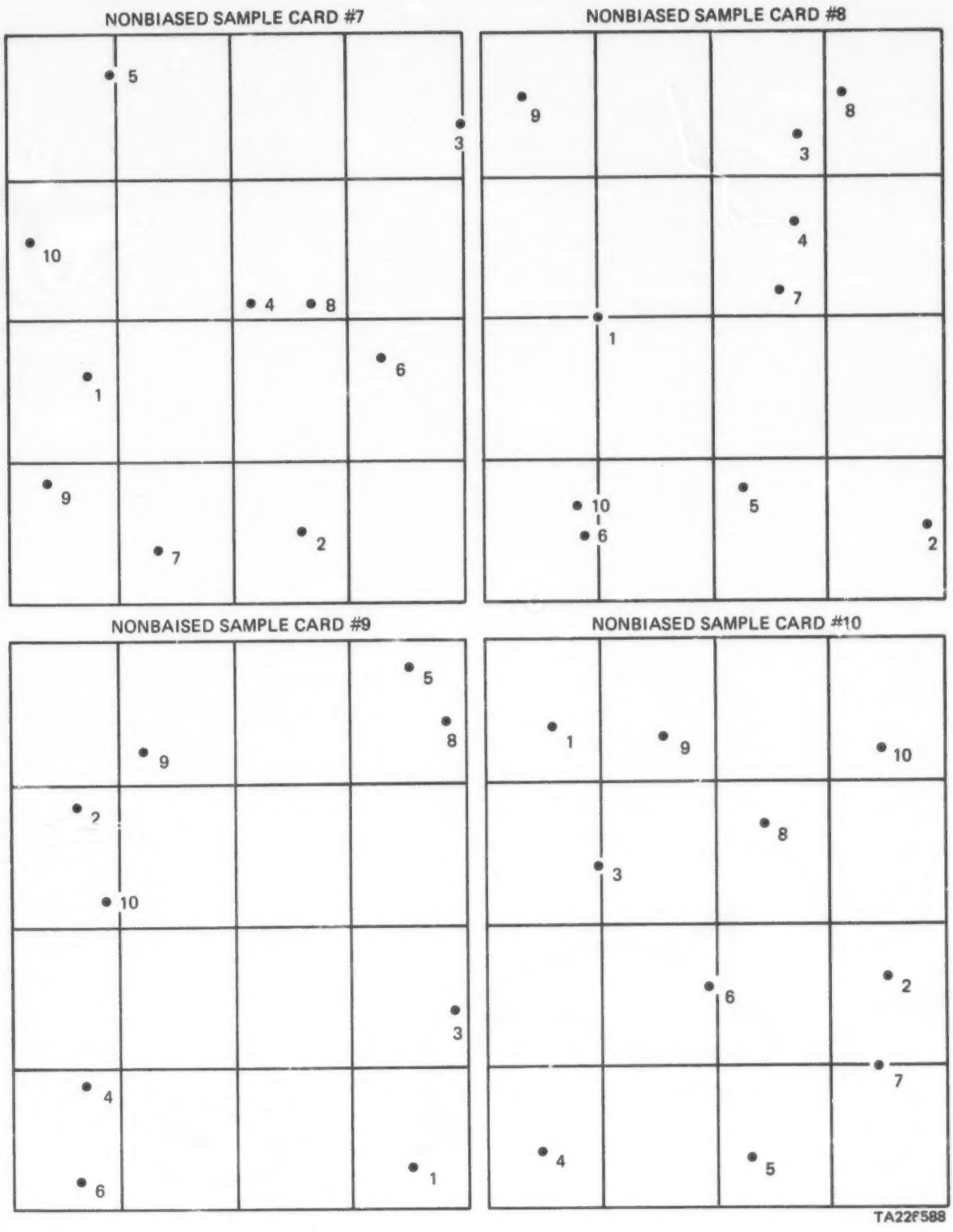

Non-Biased Random Sample Cards 7, 8, 9, and 10

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By Order of the Secretary of the Army:

JOHN A. WICKHAM, JR.
General, United States Army
Chief of Staff

Official:

MILDRED E. HEDBERG
Brigadier General, United States Army
The Adjutant General

Distribution:

To be distributed in accordance with DA Form 12–34C requirements for TB Engineer Series.

*U.S. GOVERNMENT PRINTING OFFICE: 1985–461-028:20519

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MOISTURE & DENSITY TESTER FIELD DATA WORKSHEET

DATE: _____

SITE: _____

STANDARD COUNTS

DENSITY COUNTS (ADD ZERO)

HIGH _____
SqRt + _____
AVG _____
SqRt – _____
LOW _____

√ AVG = _____

TOTAL StCt _____
AVG StCt (÷10) _____

MOISTURE COUNTS (ADD ZERO)

HIGH _____
SqRt + _____
AVG _____
SqRt – _____
LOW _____

√ AVG = _____

TOTAL StCt _____
AVG StCt (÷10) _____

A
A

FIELD COUNTS

	B/S DENSITY	TRANS. 2"	TRANS. 4"	TRANS. 6"	TRANS. 8"	B/S MOISTURE	
							b
							b
							b
TOTAL							B
AVG ÷ 3						AVG ÷ 3	C
÷ by AVG StCt							A
RESULTANT RATIO							C
WET DEN PCF						H_2O PCF	DW

DRY WEIGHT

	(BS)	(2")	(4")	(6")	(8")	
WET DEN PCF						D
LESS H_2O						DW
DRY DEN PCF						E

PERCENT COMPACTION

DRY DEN PCF						E
÷						
*SOIL MAX DEN						F
X 100 = %						G

PERCENT MOISTURE

H_2O PCF						DW
÷						
DRY DEN PCF						E
X 100 = % MOISTURE						H

* THE MAXIMUM DENSITY OF SOIL REQUIRES A PROCTOR METHOD RUN UNDER LABORATORY CONDITIONS. THIS IS NOT SUPPLIED BY THE NUCLEAR TESTER. ALL % MOISTURE IS A PERCENT OF DRY WEIGHT, NOT WET WEIGHT.

DA FORM 5448-R, AUG 85

For use of this form, see TM 5-6635-386-12&P; the proponent agency is AMC.

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MOISTURE & DENSITY TESTER (NUCLEAR METHOD) UTILIZATION LOG				
DATE	TIME PERIOD FROM TO	LOCATION OF USE	OPERATOR	REMARKS (include standard count for moisture and density)

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STANDARD COUNT	DENSITY	MOISTURE	MOISTURE & DENSITY FIELD TEST SHEET	FILE NO.
				PROJECT
			GAUGE NO.	
TOTAL			MOISTURE & DENSITY DATA	
AVERAGES				

DATE															
TEST NO.															
TEST LOCATION															
PROBE DEPTH															
DENSITY COUNTS															
TOTAL															
AVERAGES															
DENSITY RATIO															
MOISTURE COUNTS															
TOTAL															
AVERAGES															
MOISTURE RATIO															
WET DENSITY p.c.f.															
WATER p.c.f.															
% MOISTURE															
DRY DENSITY p.c.f.															
% RELATIVE COMPACTION															

DA FORM 5450-R, AUG 85

For use of this form, see TM 5-6635-386-12&P; the proponent agency is AMC.

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RECOMMENDED CHANGES TO EQUIPMENT TECHNICAL PUBLICATIONS

SOMETHING WRONG WITH THIS PUBLICATION?

FROM: (PRINT YOUR UNIT'S COMPLETE ADDRESS)
Your mailing address

DATE SENT
Date you filled out form.

PUBLICATION NUMBER	PUBLICATION DATE	PUBLICATION TITLE
TM 9-XXXX-XXX-XX	Date of TM	Title of TM

BE EXACT . . . PIN-POINT WHERE IT IS

PAGE NO	PARA-GRAPH	FIGURE NO	TABLE NO
400		183	
512		191	

IN THIS SPACE TELL WHAT IS WRONG AND WHAT SHOULD BE DONE ABOUT IT:

Change illustration. Reason: Tube end shown assembled on wrong side of lever cam.

Figure 191, item 3 has the wrong NSN. Supply rejects orders for this item. The NSN shown here is not listed in the AMDF or the MCRL.

Please give us the correct NSN and P/N.

SAMPLE

PRINTED NAME, GRADE OR TITLE, AND TELEPHONE NUMBER
JOHN SMITH, S. SGT. 793/XXXX

SIGN HERE
John Smith

DA FORM 1 JUL 79 2028-2

PREVIOUS EDITIONS ARE OBSOLETE.

P.S.--IF YOUR OUTFIT WANTS TO KNOW ABOUT YOUR RECOMMENDATION MAKE A CARBON COPY OF THIS AND GIVE IT TO YOUR HEADQUARTERS

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RECOMMENDED CHANGES TO EQUIPMENT TECHNICAL PUBLICATIONS

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PUBLICATION NUMBER	PUBLICATION DATE	PUBLICATION TITLE
TM 5-6635-386-12&P	SEPT 85	Tester, Density & Moisture

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THE METRIC SYSTEM AND EQUIVALENTS

LINEAR MEASURE

1 Centimeter=10 Millimeters=0.01 Meters=0.3937 Inches
1 Meter=100 Centimeters=1000 Millimeters=39.37 Inches
1 Kilometer=1000 Meters=0.621 Miles

WEIGHTS

1 Gram=0.001 Kilograms=1000 Milligrams=0.035 Ounces
1 Kilogram=1000 Grams=2.2 Lb
1 Metric Ton=1000 Kilograms=1 Megagram=1.1 Short Tons

LIQUID MEASURE

1 Milliliter=0.001 Liters=0.0338 Fluid Ounces
1 Liter=1000 Milliliters=33.82 Fluid Ounces

SQUARE MEASURE

1 Sq Centimeter=100 Sq Millimeters=0.155 Sq Inches
1 Sq Meter=10,000 Sq Centimeters=10.76 Sq Feet
1 Sq Kilometer=1,000,000 Sq Meters=0.0386 Sq Miles

CUBIC MEASURE

1 Cu Centimeter=1000 Cu Millimeters=0.06 Cu Inches
1 Cu Meter=1,000,000 Cu Centimeters=35.31 Cu Feet

TEMPERATURE

5/9 (°F - 32) = °C
212° Fahrenheit is equivalent to 100° Celsius
90° Fahrenheit is equivalent to 32.2° Celsius
32° Fahrenheit is equivalent to 0° Celsius
9/5 C° +32=F°

APPROXIMATE CONVERSION FACTORS

TO CHANGE	TO	MULTIPLY BY
Inches	Centimeters	2.540
Feet	Meters	0.305
Yards	Meters	0.914
Miles	Kilometers	1.609
Square Inches	Square Centimeters	6.451
Square Feet	Square Meters	0.093
Square Yards	Square Meters	0.836
Square Miles	Square Kilometers	2.590
Acres	Square Hectometers	0.405
Cubic Feet	Cubic Meters	0.028
Cubic Yards	Cubic Meters	0.765
Fluid Ounces	Milliliters	29.573
Pints	Liters	0.473
Quarts	Liters	0.946
Gallons	Liters	3.785
Ounces	Grams	28.349
Pounds	Kilograms	0.454
Short Tons	Metric Tons	0.907
Pound-Feet	Newton-Meters	1.356
Pounds per Square Inch	Kilopascals	6.895
Miles per Gallon	Kilometers per Liter	0.425
Miles per Hour	Kilometers per Hour	1.609

TO CHANGE	TO	MULTIPLY BY
Centimeters	Inches	0.394
Meters	Feet	3.280
Meters	Yards	1.094
Kilometers	Miles	0.621
Square Centimeters	Square Inches	0.155
Square Meters	Square Feet	10.764
Square Meters	Square Yards	1.196
Square Kilometers	Square Miles	0.386
Square Hectometers	Acres	2.471
Cubic Meters	Cubic Feet	35.315
Cubic Meters	Cubic Yards	1.308
Milliliters	Fluid Ounces	0.034
Liters	Pints	2.113
Liters	Quarts	1.057
Liters	Gallons	0.264
Grams	Ounces	0.035
Kilograms	Pounds	2.205
Metric Tons	Short Tons	1.102
Newton-Meters	Pound-Feet	0.738
Kilopascals	Pounds per Square Inch	0.145
Kilometers per Liter	Miles per Gallon	2.354
Kilometers per Hour	Miles per Hour	0.621

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